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1830

ELEMENTS

OF THE

Theory and Practice

OF

CHYMISTRY.

TRANSLATED

Pierre Joseph

From the French of M. MACQUER,

Member of the Royal Academy of Sciences, and Profeſſor of Medicine in the Univerſity of Paris.

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ELEMENTS OF THE PRACTICE of CHYMISTRY.

PART I. SECTION III.

Of Operations on the SEMI-METALS.

CHAP. I.

Of ANTIMONY.

PROCESS I.

To ſeparate Antimony from its Ore by Fuſion.

HAVING drilled ſome ſmall holes, of about two lines diameter, in the bottom of a crucible, put into it your Antimonial ore broken into little bits, about the ſize of a hazel nut; lute on its cover; ſet the crucible thus prepared in the mouth of another crucible, and cloſe the joints with lute.

At the diſtance of half a foot from this compound veſſel place bricks all round, ſo as to form a furnace; the ſides of which muſt riſe as high as the brim of the uppermoſt crucible.

Let the bottom of this furnace be filled with aſhes, up to the top of the lower crucible, and the reſt of the furnace with lighted coals. Blow the fire, if it be neceſſary, with bellows, till the upper crucible become red. Keep it up in this degree for about a quarter of an hour. Then take your veſſels out of the furnace, and you will find the Antimony collected in the bottom of the lower crucible, having run through the holes of the upper one.

OBSERVATIONS.

THE ore of Antimony is one of the moſt fuſible: it always contains a great deal of Sulphur; and cannot ſuſtain a fire of any force without being diſſipated into vapours. It requires no additament to flux it; for it is not neceſſary, on this occaſion, that the earthy and ſtony matters mixed therewith be brought to fuſion. It is ſufficient that the Antimonial part be melted; which, as ſoon as it becomes fluid, is carried by its weight to the lower part of the crucible. Thus it is ſeparated from all heterogeneous matters; which are left in the upper crucible, while it paſſes through the holes in its bottom, and forms a maſs in the lower.

The precaution of cloſing all the openings of both crucibles is neceſſary, on account of the volatility of this mineral: and that the Antimony, when once melted, may not continue expoſed to a great heat, it is made to run down into a veſſel ſurrounded with aſhes only, and by that means very little affected with heat; aſhes being one of thoſe ſolid mediums that tranſmit leaſt of it.

PROCESS II.

The common Regulus of Antimony.

REDUCE crude Antimony to powder. Mix it with three fourths of its weight of white Tartar, and half its weight of refined Salt-petre, both pulverized. Into a large crucible made red hot in the fire, throw a ſpoon-full of your mixture, and cover it. There will be a very conſiderable detonation. When it is over, throw in a ſecond ſpoon-full of your mixture, and cover the crucible as before: this will produce a ſecond detonation. Go on thus, till you have thrown in all your mixture.

When the whole has thus fulminated, increaſe the fire ſo as to bring the matter into fuſion; that being done, take the crucible out of the furnace, and immediately pour its contents into an iron cone heated and greaſed with tallow. Strike the floor and the cone ſome gentle blows with a hammer, to make the Regulus precipitate; and when the matter is fixed and cold, invert the cone and turn it out. You will ſee it conſiſt of two diſtinct ſubſtances; the uppermoſt of which is a ſaline ſcoria, and the undermoſt the reguline part. Strike this maſs a blow with a hammer, in the place where theſe ſubſtances join, and you will by this means ſeparate the ſcoria from the Regulus; the latter of which will have the form of a metallic cone, on whoſe baſe you will obſerve the ſignature of a bright ſtar.

OBSERVATIONS.

ANTIMONY, though ſeparated by a former fuſion from the earthy and ſtony parts of its ore, muſt nevertheleſs be ſtill conſidered as an ore, on account of the great quantity of Sulphur it contains, which mineralizes the metalline part or Regulus. Therefore if you deſire to have this Regulus pure, you muſt ſeparate it from the Sulphur that is combined with it. This may be done ſeveral ways. The method above propoſed is one of the readieſt and eaſieſt, though not altogether free from inconveniencies, as we ſhall ſhew.

The Salt-petre in the mixture detonates by means of the Sulphur of the Antimony, which it conſumes, and from which it ſeparates the reguline part: but leſt it ſhould alſo conſume ſome of the phlogiſton which gives the regulus its metalline form, Tartar is added; becauſe it contains a great deal of inflammable matter, and ſo is capable of furniſhing enough for the detonation of the Nitre, or rather for reſtoring to the metallic earth of the Antimony the phlogiſton that may be conſumed by the Nitre.

If we conſider what paſſes in this operation we ſhall ſoon be convinced that a great deal muſt be loſt in it, and that we do not thereby obtain near all the Regulus that the Antimony is capable of yielding: for 1. the Regulus of Antimony being a volatile ſubſtance, much of it muſt be diſſipated during the detonation; and ſo much the more as the detonation is ſeveral times repeated, and continued for a conſiderable ſpace. The flowers that may be collected by preſenting cold bodies to the ſmoke that riſes in the operation, and which may be reduced to a Regulus by the addition of a phlogiſton, ſufficiently prove what is here advanced.

2. All the Sulphur of the Antimony is not conſumed by the Nitre on this occaſion; and moreover, the Acid of that part thereof which is burnt, uniting with ſome of the Alkali produced by the deflagration of the Nitre and Tartar, forms a Vitriolated Tartar, which meeting with a ſufficient quantity of phlogiſton in the mixture produces new Sulphur. Now this Sulphur, whether not conſumed, or re-produced, in the operation, combining with the Alkali forms a Liver of Sulphur; and that diſſolves part of the Regulus, which by this means remains confounded with the ſcoria. The proof of this is, that, if the ſcoria be mixed with filings of iron, and fuſed a ſecond time, you will find at the bottom of the crucible a button of Regulus which it contained, and which is ſeparated therefrom by the interpoſition of the Iron. We ſhall ſay more on this ſub-

ject in the proceſs for making the Martial Regulus, which immediately follows this. If, inſtead of melting the ſcoria with iron filings, we pulverize it, boil it in water, and then pour an acid into that water; the liquor will inſtantly grow turbid, and a Sulphureous Precipitate will fall, commonly called the *Golden Sulphur of Antimony*; which is nothing elſe but common Sulphur ſtill combined with ſome particles of the Regulus: a new proof of what we advanced concerning the production of Liver of Sulphur in this operation.

As Regulus of Antimony is of no great value, the loſs ſuſtained in this proceſs is ſeldom regarded. However, we ſhall have occaſion in the ſequel to point out a method of obtaining this Regulus with leſs diſadvantage.

PROCESS III.

Regulus of Antimony precipitated by Metals.

PUT one part of ſmall iron nails into a crucible, and ſet it amidſt burning coals, in a melting furnace. When the iron is thoroughly red-hot, and begins to grow white, add thereto little by little, and at ſeveral times, two parts of crude Antimony in powder. The Antimony will immediately flow and unite with the Iron. When the Antimony is entirely melted, add thereto, at ſeveral times, the fourth of its weight of pulverized Nitre: a detonation will enſue, and the whole mixture will be in fuſion.

After you have kept the matter in this condition for ſome minutes, pour it into an iron cone, firſt heated and tallowed. Strike the ſides of the cone with a hammer, that the Regulus may fall to the bottom; and, when all is cold, ſeparate it from the ſcoria by a blow with a hammer. Melt this firſt

Regulus again in another crucible, adding a fourth part of its weight of crude Antimony. Keep the crucible cloſe ſhut, and give no more heat than is neceſſary to melt the matter. When it is in perfect fuſion, add to it at ſeveral times, as you did before, the ſixth part of its weight of pulverized Nitre; and, in half a quarter of an hour after this, pour the whole into a cone as you did the firſt time.

Laſtly, melt your Regulus over again a third or even a fourth time, always adding a little Nitre, which will detonate as before. If after all theſe fuſions you pour the Regulus into an iron cone, you will find it very beautiful, and the ſtar well formed: it will be covered with a ſemi-tranſparent, lemon coloured ſcoria. This ſcoria is extremely acrid and cauſtic.

OBSERVATIONS.

THOUGH Regulus of Antimony unites very readily with Sulphur, and is always found combined therewith in the earth, we muſt not thence conclude that it hath a greater affinity than other ſubſtances with that mineral: on the contrary, all the metals, except Gold, have a greater affinity than this Semi-metal with Sulphur. Hence it follows that all the metals, except Gold, are capable of decompoſing Antimony, and ſeparating the ſulphureous part from the metalline; ſo that, inſtead of employing Iron, as in our proceſs, Copper, Lead, Tin, or Silver, may be uſed, and a Regulus obtained by means thereof.

But as Iron is, of all the metallic ſubſtances, that which hath the greateſt affinity with Sulphur, it is on this occaſion preferred to the reſt. And from hence two advantages ariſe: the firſt is, that the operation is performed ſooner and with greater eaſe; the ſecond, that the Regulus is purer, and contains leſs of the precipitating metal. For it is a general rule, that, when one metallic ſubſtance is employed to precipitate another, the precipitated ſubſtance is always a little adulterated by the admixture of ſome particles of the precipitant. Now, the greater affinity the precipitant hath with the matter united to that which is to be precipitated, the leſs doth the precipitate retain of the precipitant.

In this proceſs the Iron melts very eaſily by means of the union it contracts with the Sulphur; which, as we obſerved before, hath the property of rendering this metal very fuſible, though of itſelf the moſt refractory of all.

The ſcoria found on the Regulus of the firſt fuſion is a combination of Iron with the ſulphureous part of the Antimony. This ſcoria is extremely hard, and not to be ſeparated from the Regulus without ſome trouble. The Nitre added, being alkalizated and uniting therewith, renders it a little ſofter, and gives it the property of relenting in the air. Any Alkaline Salt may be ſubſtituted for the Nitre.

The Nitre that is alkalizated in the operation, or the Alkali that is added, procures moreover another advantage; namely, that, by uniting with part of the Sulphur of the Antimony, it produces a Liver of Sulphur, which diſſolves the Iron, retains it, and hinders that which is not yet combined with pure Sulphur from uniting ſo readily with the Regulus as it otherwiſe would do.

Laſtly, the addition of Nitre, or an Alkali, contributes greatly to promote the fuſion, to render it more perfect, and to procure a more complete precipitation of the Regulus.

The ſecond fuſion which the Regulus is made to undergo is intended to purify it from any mixture of Iron. When the freſh Antimony added on that occaſion comes to melt with the Regulus, the Sulphur contained in the Antimony joins with the ferruginous parts in the Regulus; and the Iron becoming lighter by this union is thrown up to the ſurface of the matter. There it forms a ſort of ſcoria, with which a good deal of Antimony is mixed; the Regulus not being wholly precipitated, becauſe there is not Iron enough in the mixture for that purpoſe. The Salt-petre added here produces the ſame effect as in the firſt fuſion.

But if, on one hand, the Regulus precipitated in the firſt fuſion be purified, by this addition of freſh Antimony, from moſt of the Iron with which it was alloyed; on the other hand this ſame Regulus cannot be kept from re-uniting with ſome ſulphureous parts.

In order therefore to ſeparate it entirely from theſe, it muſt be melted over again once or twice more, and a little Nitre added each time, to conſume them by deflagration. But this cannot be done without conſuming alſo ſome of the very phlogiſton which gives the Regulus its metalline form: whence it comes to paſs that part of the Regulus is converted to a calx, which by means of the alkalizated Nitre is turned into glaſs; and it is this glaſs which mixing with the ſcoria gives it the yellow colour obſerved therein. This yellow colour may alſo be in part produced by ſome ferruginous particles, of which a ſmall quantity always remains combined with the Regulus, notwithſtanding its former depuration by Antimony.

It is of no uſe to repeat the fuſions of the Regulus oftener than is above propoſed, or to add freſh Nitre with a view to conſume the Sulphur it may ſtill contain: for after the ſecond fuſion it contains none at all, and retains only the phlogiſton neceſſary to give it the metalline form. So that, by proſecuting the matter further, you would only calcine and deſtroy the Regulus to no manner of purpoſe.

From what hath been ſaid it is plain that, even by this proceſs, we do not obtain all the Regulus which our Antimony is capable of yielding; ſeeing part of it is deſtroyed by the fuſions it muſt neceſſarily undergo with Nitre, in order to its purification. We ſhall give a proceſs for obtaining from Antimony the greateſt quantity of Regulus it can poſſibly be made to yield, after we have treated of its Calcination, which is in ſome ſort the firſt ſtep of that proceſs.

PROCESS IV.

The Calcination of Antimony.

TAKE an unglazed earthen veſſel, wider at top than at bottom; put into it two or three ounces of crude Antimony finely pulverized. Set this veſſel over a weak charcoal-fire, and increaſe the heat till you ſee the Antimony begin to ſmoke a little. Continue the fire in this degree, and keep inceſſantly ſtirring the Antimony with the ſhank of a tobacco pipe all the while it is upon the fire.

The powder of Antimony, which, before calcination, was of a brilliant colour inclining to black, will become dull, and look like an earth. When it comes to have this appearance raiſe your fire till the veſſel be red-hot, and keep it up in this degree till the matter ceaſe entirely to ſmoke.

OBSERVATIONS.

ANTIMONY, as hath been already ſaid, is a ſort of ore conſiſting of a metalline or reguline part mineralized by Sulphur.

The deſign of this calcination is, by the action of fire, to diſſipate the ſulphureous part, which is the moſt volatile, in order to ſeparate it from the metalline part. It is evidently a real torrefaction; but the operation is very difficult, and requires a good deal of attention: for Antimony very eaſily melts, while at the ſame time it is neceſſary to our ſucceſs that it do not melt; becauſe when the matter is in fuſion the Sulphur requires a much greater degree of heat to carry it off. Now, as Regulus of Antimony itſelf is very volatile, a good deal of it would be diſſipated along with the Sulphur, if it were expoſed to the degree of heat neceſſary to carry off the Sulphur when the maſs is melted.

Therefore if it happen that the Antimony begin to melt during the calcination, which is eaſily perceived by its running into clots, it muſt be taken off the fire, and the clotted parts be again pulverized; after which the calcination is to be proſecuted with a leſs degree of heat.

When the Antimony has loſt all its brightneſs, and is become like an earthy matter, it is time to augment the degree of heat, in order to complete the calcination; becauſe the laſt portions of the Sulphur are the moſt difficult to raiſe. Moreover, the inconveniencies juſt mentioned are not now to be apprehended: for, as the great fuſibility of the reguline part is owing to the Sulphur, what remains, after you have diſſipated the greateſt part of the Sulphur, is much leſs fuſible; and, as the redundant Sulphur of the Antimony cannot be driven off, without diſſipating at the ſame time a good deal of the phlogiſton neceſſary to metallize its Regulus, the matter that remains comes much nearer to the nature of a calx, than to that of a metalline ſubſtance; and conſequently partakes of the nature of all metallic calxes, which is to be very fixed.

Antimony may alſo be calcined by mixing with that mineral an equal quantity of charcoal-duſt. As charcoal is incapable of fuſion, it prevents the Antimony from clotting, as well as from loſing ſo much of its metallizing phlogiſton as it otherwiſe would: and hence it comes to paſs that the calx of Antimony, prepared in this manner, comes nearer to the nature of a Regulus, than that which is prepared without addition.

If you happen to raiſe the fire too much, in this calcination with charcoal-duſt, the calx will be partly reduced to a Regulus, by means of the phlogiſton which the charcoal furniſhes; and then the Regulus will be diſſipated in vapours, eſpecially as this calx, which comes very near the nature of a Regulus, is not ſo fixed as that prepared without addition. For this reaſon it always continues to ſmoke, even when it contains no ſuperfluous Sulphur: and therefore you muſt not wait till it ceaſe to ſmoke before you put an end to your calcination; for you will loſe a great deal of it in vapours. It is time to ſtop when the vapours that riſe from it, while it is moderately red, do not ſmell of burning Sulphur.

PROCESS V.

Calx of Antimony reduced to a Regulus.

MIX the calx of Antimony, which you intend to reduce, with an equal quantity of black ſoap. This mixture will make a thin paſte. Put it little by little into a crucible, previouſly made red-hot amidſt live coals. Thus let the ſoap burn, till it ceaſe to emit an oily ſmoke. Then cover the crucible; make the fire ſtrong enough to melt the matter, and you will hear it effervеſce and boil. When this noiſe is over let the crucible cool, and then break it: you will find in it a beautiful ſcoria, marked with circles of ſeveral colours; and under that a button of Regulus, which is not yet quite pure, and muſt be purified in the following manner.

Pound this Regulus, and mix it with half its weight of an antimonial calx as perfectly deſulphurated as poſſible. Put it into a crucible, and cover it: melt the whole, ſo that the ſurface of the melted matter may be ſmooth and uniform. Let the crucible cool, and then break it: you will find in it a beautiful button of very pure Regulus, covered with a ſcoria having the appearance of an opaque glaſs, or a kind of greyiſh enamel, moulded on the finely radiated ſurface of the Regulus.

OBSERVATIONS.

OF all the metalline calxes that of Antimony is moſt eaſily reduced. Any matter that contains the phlogiſton, even charcoal-duſt alone is ſufficient to procure it the form of a Regulus, without the addition of any thing to facilitate its fuſion; becauſe this calx, which is not of itſelf altogether refractory, becomes ſtill more fuſible as it combines with the phlogiſton, and approaches to the reguline ſtate.

Though all inflammable matters are capable of procuring the reduction of the calx of Antimony, yet there are ſome with which the operation ſucceeds better, and produces a greater quantity of Regulus, than it does with others. Fatty matters, joined with Alkalis, are thoſe which anſwer beſt in this reduction, as they do in moſt others. The black flux, for inſtance, is very proper for this purpoſe: but Mr. Geoffroy, who made many experiments on Antimony, found by repeated trials that black ſoap is ſtill fitter for it, and that a greater quantity of Regulus was obtained by its means, than by any other reducing flux whatever. The proceſs here given is taken from one of the Memoirs on this ſubject which he laid before the Academy of Sciences.

Black ſoap is made of the lye of a fixed Alkali, ſuch as pot-aſh for inſtance, with quick-lime, incorporated by boiling with oil of lint-ſeed, rape-ſeed, or hemp-ſeed, and ſometimes alſo with animal fat. The oily matters, contained in this reducing flux, are firſt burnt and charred to a coal in the crucible. As ſoon as they are brought to this ſtate, the crucible is covered, and the fire is encreaſed, till the matters melt. At that inſtant the reduction begins to take place; and the bubbling noiſe obſerved is an effect thereof.

The Regulus obtained by this firſt fuſion is not yet very pure, being adulterated with the mixture of ſome unmetallic earth that was contained in the Antimony, and with a portion of the calcarious earth of the ſoap.

Mr. Geoffroy found that his Regulus was contaminated with this ſubſtance, by putting it into water: for on that occaſion he obſerved a very briſk ebullition about the reguline buttons, which ſometimes laſted above four and twenty hours; and on examining them with a glaſs, he diſcovered ſome little holes, imperceptible to the naked eye, through which the water entered, to unite with the lime retained in the internal parts of the Regulus, which having been re-calcined in the operation required to be ſlaked.

This Regulus may be purified by ſimple fuſion, without any additament, becauſe the particles of lime, being lighter than thoſe of the Regulus, will be thrown up to the ſurface, on which they will form a ſort of ſcoria. But Mr. Geoffroy took notice that, in this caſe, the ſurface of the Regulus is never very neat; that it is always ſullied with a very adheſive ſcoria, and that no ſtar is formed upon it. Beſides, the Regulus muſt be kept a long while in very thin fuſion, that the heterogeneous matters, which hinder the perfect re-union of its parts, may have time to riſe to the ſurface by their lightneſs. But the longer the Regulus is kept in fuſion, the more of it evaporates, becauſe of its volatility. He was therefore obliged to have recourſe to other means.

We have in the proceſs deſcribed the method which ſucceeded beſt with Mr. Geoffroy. It conſiſts in melting the Regulus over again, with the addition of a little freſh calx of Antimony thoroughly freed from its Sulphur. This calx being in its nature eaſily vitrifiable, and combining with the earthy parts that deprave the Regulus, and which cannot be vitrified without addition, ſcorifies theſe matters, and with them forms the opaque glaſs, or kind of enamel which is found over the Regulus purified in this manner.

The ſtar on that part of the Regulus of Antimony, which was contiguous to the ſcoria, is a mark of its purity, and a proof that the operation was well performed. This ſtar is nothing but a particular diſpoſition of the parts of the Antimony, which have the property of running naturally into facets and needles. The perfect fuſion, both of the Regulus and the ſcoria that covers it, leaves the parts of the Regulus at liberty to range themſelves in this order. This diſpoſition appears not only on the upper ſurface of the Regulus, but, if you break the button, you find the ſame in its internal parts. There are ſome round pyrites whoſe inſides have nearly the ſame appearance, and ſeem to conſiſt of rays iſſuing from a common center.

The quantity of Regulus obtained by Mr. Geoffroy's proceſs is more than double of what is procured in the common way, which yields but about four ounces in the pound; whereas this gives from eight to ten ounces.

When Antimony is calcined with charcoal-duſt, what remains after the diſſipation of all the Sulphur is not, properly ſpeaking, a calx of Antimony; but a ſort of Regulus quite formed, and differing from the common Regulus only in that its parts are diſunited, and not collected into a maſs. For if this pretended calx of Antimony be melted, it directly coaleſces into a Regulus, without the addition of any inflammable matter fit to procure its reduction.

tion. Indeed leſs Regulus is obtained by this means than when a reductive is added : but nevertheleſs this experiment ſtill proves what I advanced ; ſeeing Regulus of Antimony cannot be melted without loſing more or leſs thereof, either becauſe ſome of it is diſſipated in vapours, or becauſe part of it loſes its phlogiſton in the fuſion, and ſo is converted into a calx.

PROCESS VI.

Antimony calcined with Nitre. Liver of Antimony. Crocus Metallorum.

PULVERIZE and mix perfectly together equal parts of Nitre and Antimony : put the mixture into an iron mortar, and cover it with a tile, which however muſt not ſhut it quite cloſe. With a live coal ſet fire to the matter in the mortar, and immediately withdraw it. The mixture will flame, with great detonation ; which being over, and the mortar cooled, invert it, and ſtrike its bottom to make all the matter fall out. Then, by a blow with a hammer, ſeparate the ſcoria from the ſhining part, which is the *Liver of Antimony*.

OBSERVATIONS.

IN this operation the Nitre takes fire and detonates with the Sulphur of the Antimony ; and nothing remains but the metallic earth of the mineral, which, meeting with no ſubſtance to reſtore its phlogiſton, cannot take the form of a Regulus ; but, being combined with a large quantity of fuſed ſaline matters, begins itſelf to flow, and forms a ſort of vitrification ; which however is not a complete one, becauſe the matters do not continue long enough in fuſion, but cool too ſoon. This preparation of Antimony is a violent Emetic. It is uſed to make Emetic Wine and Tartar Emetic: it is alſo given in ſubſtance to horſes.

The ſaline matters found after the operation in the form of a ſcoria, or perhaps confounded with the Liver of Antimony, are combinations of Fixed Nitre, partly with the Acid of the burnt Sulphur, forming a Neutral Salt of the ſame kind as Vitriolated Tartar, and partly with ſome unburnt Silphur, forming a ſort of Liver of Sulphur that contains a little Regulus. It is uſual to pulverize this Liver of Antimony and waſh it with water, in order to diſſolve and carry off all the Salts. When thus pulverized and waſhed it is called *Crocus Metallorum.* If Liver of Antimony be melted with any inflammable matter, it will be reduced to a Regulus; becauſe it is nothing but a metalline calx half vitrified.

PROCESS VII.

Another Calcination of Antimony with Nitre. Diaphoretic Antimony. Materia Perlata. Clyſſus *of Antimony.*

MIX one part of Antimony with three parts of Nitre; project this mixture by ſpoon-fulls into a crucible kept red-hot in a furnace. Each projection will be attended with a detonation. Continue doing this till you have uſed all your mixture: then raiſe the fire, and keep it up for two hours; after which throw your matter into a pan full of hot water. Let it lie ſteeping in water kept hot for a whole day. Then pour off the liquor: waſh the white powder you find at bottom in warm water; and repeat the ablutions till the powder become inſipid. Dry it, and you have *Diaphoretic Antimony.*

OBSERVATIONS.

THIS operation differs from the preceding one, in reſpect of the quantity of Nitre deflagrated with the Antimony. In the former we added one part only of Nitre to one part of Antimony; but in this three parts of Nitre are put to one of the mineral; and the calx reſulting from this mixture is of courſe very different from the other.

In the firſt place, Liver of Antimony hath a rediſh colour; whereas Diaphoretic Antimony is very white. Secondly, Liver of Antimony is in a manner half vitrified; Diaphoretic Antimony is, on the contrary, in the form of a powder, the parts of which have no connection together.

The reaſon of theſe differences will eaſily appear, if we conſider, that, Liver of Antimony being the reſult of calcination with one part of Nitre only, which is not ſufficient to conſume all the Sulphur of the mineral, what remains after the detonation is not entirely deprived of its phlogiſton; from whence ariſe the colour it retains and the eaſe with which it flows in the fire: but that, when three parts of Nitre are added inſtead of one, this quantity is not only ſufficient to conſume all the Sulphur and the phlogiſton of the Antimony, but even more than enough; ſeeing that, after the operation, ſome Nitre is ſtill found undecompoſed.

The calx of Antimony, prepared by calcining it with three parts of Nitre, is therefore deprived of all its phlogiſton. This is the cauſe of its whiteneſs, and the reaſon why it is not half vitrified by the operation, as Liver of Antimony is: for we know that the more a metallic calx is deprived of its phlogiſton, the leſs fuſible and the leſs vitrifiable it is. This calx of Antimony bears the name of *Diaphoretic Antimony*, or *Diaphoretic Mineral*; becauſe, being neither emetic nor purgative, it is thought to have the virtue of promoting perſpiration.

Antimony may be calcined with various proportions of Nitre, between that uſed to make Liver of Antimony, and this with which Diaphoretic Antimony is prepared; and from theſe calcinations will reſult calxes poſſeſſed of properties, both chymical and medical, of an intermediate nature between the extremes of thoſe two preparations. The nearer the proportion of Nitre comes to that employed in preparing Liver of Antimony, the more will the reſulting calx reſemble that preparation; and in the ſame manner, a calx prepared with a greater proportion of Nitre will ſo much the more reſemble Diaphoretic Antimony, as the proportion of Nitre uſed comes nearer three parts of Nitre for one of Antimony.

It is not neceſſary that Antimony in ſubſtance be employed to make the Diaphoretic Mineral: you may, if you pleaſe, make uſe of its Regulus But as the Regulus contains no Sulphur, nor any more phlogiſton than is requiſite to ſecure its metalline form, it is needleſs to put three parts of Nitre to one of Regulus; an equal quantity thereof being ſufficient.

The matter is projected by ſpoonfulls, to the end that, by gradual and repeated detonations, the Antimony may be more perfectly calcined: it is alſo with a view to deſtroy entirely the ſmall remainder of phlogiſton, which may have eſcaped the action of the Nitre, that the matter is kept red-hot in the crucible for two hours.

The whole is afterwards thrown into hot water, and left ſteeping therein for ſeveral hours, with deſign to give the water time to diſſolve all the ſaline matters that are mixed with the Diaphoretic Calx. When crude Antimony is uſed in making this preparation, theſe ſaline matters are 1. an Alkalizated Nitre; 2. a Neutral Salt formed by the union of the Acid of Sulphur with part of that Alkali, as in the preparation of Liver of Antimony; 3. a portion of undecompoſed Nitre.

The water in which the Diaphoretic is waſhed takes up moreover a portion of the calx of Antimony, which is exceeding finely attenuated, and continues united with the Fixed Nitre, and ſuſpended therewith in the liquor. This matter is to be ſeparated from the Fixed Nitre, by mixing the water wherein it is diſſolved with an Acid, which unites with the Alkali, and precipitates this matter in the form of a white powder, to which the name of *Materia Perlata* hath been given. Becauſe it is precipitated in the ſame manner as the Golden Sulphur of Antimony, and, like that, is found in the water with which the ſaline matters are waſhed out, after the detonation of Nitre with Antimony, ſome Chymiſts have given it, though very improperly, the name of the *Fixed Sulphur of Antimony*.

This matter is a true Calx of Antimony, and differs from Diaphoretic Antimony in nothing but its being ſtill more perfectly calcined. It is ſo indeed to ſuch a degree that it is impoſſible to reſtore its metalline form, or reduce it to a Regulus, by the addition of an inflammable matter. Diaphoretic Antimony, on the contrary, may be re-metallized, by ſupplying it with phlogiſton: but it muſt be obſerved that, in whatever manner you go about this, you will obtain a much ſmaller quantity of Regulus, than when you uſe a Calx of Antimony prepared with a ſmaller quantity of Nitre.

If you attempt to reduce either Liver of Antimony or Diaphoretic Antimony, great care muſt be taken to waſh them thoroughly, in order to free them from every thing ſaline: for, without this precaution, the Acid of the Sulphur, having, as was obſerved, formed a Neutral Salt with the Alkali of the Nitre, will combine with the inflammable matter added to re-vivify the calx of Antimony and re-produce a Sulphur; which, uniting afterwards with the ſame Alkali, will produce a Liver of Sulphur, that will diſſolve part of the Regulus, hinder its precipitation, and greatly leſſen the quantity which might otherwiſe be expected.

A particular ſort of Diaphoretic Antimony is ſometimes prepared for Medical uſes, which hath a purgative quality: it is not waſhed at all, and is therefore called *Unwaſhed Diaphoretic Mineral.*

Diaphoretic Antimony may alſo be prepared in cloſe veſſels, by means of which the vapours that riſe during the operation are retained. For this purpoſe a tubulated retort is employed, having a ſeries of adopters fitted to it. The retort is placed in a furnace, and heated till its bottom become red: then a very ſmall quantity of the mixture, for making Diaphoretic Antimony, is introduced through the tube in the upper part of the retort, and the tube immediately ſtopped. A detonation enſues, and the vapours expand themſelves into the adopters, where they condenſe. This is repeated till the intended quantity of matter be uſed. After the operation ſome white flowers are found ſublimed into the neck of the retort, and a ſmall quantity of liquor in the recipients. This liquor is acid. It conſiſts of ſome of the Acid of the Nitre, which the Acid of the Sulphur hath expelled from its baſis, and alſo a little of the Acid of the Sulphur carried up by the heat before it could combine with the baſis of the Nitre. This liquor is called *Clyſſus of Antimony*. The name of *Clyſſus* is given to all liquors in general that are prepared by this method.

The white flowers found in the neck of the retort are flowers of Antimony; that is, a calx of Antimony forced up by the heat and by the impetus of the detonation. Theſe flowers may be reduced to a Regulus. What remains in the retort is the ſame with the matter that remains in the crucible wherein the mixture of Nitre and Antimony for making Diaphoretic Antimony hath been deflagrated.

Neither Diaphoretic Antimony nor the Pearly matter are ſoluble in any Acid.

PROCESS VIII.

Calx of Antimony Vitrified.

TAKE any quantity you pleaſe of calx of Antimony, made without addition; put it into a good crucible, which ſet in a melting furnace: kindle the fire gradually, and leave the crucible uncovered at the beginning.

A quarter of an hour after the matter is red-hot, cover the crucible, and excite the fire vigorouſly till the calx melt. You may know when it is thoroughly melted, by dipping into the crucible an iron wire, to the end of which a little knob of glaſs will adhere, if the matter be in perfect fuſion. Keep it in fuſion for a quarter of an hour, or rather longer if your crucible can bear it. Then take it out of the furnace, and immediately pour out the melted matter on a ſmooth ſtone, made very hot for the purpoſe: it will preſently fix into a yellow Glaſs.

OBSERVATIONS.

ALL the calxes of Antimony, when expoſed to a violent fire, are converted into Glaſs, but not all with the ſame facility. In general, the more of their phlogiſton they have loſt in the calcination, the more difficult is their vitrification. This cauſes alſo a difference in the colour of the Glaſs; which will be of ſo much a deeper yellow, and the nearer to a red, the leſs the Antimony was calcined.

It frequently happens, when we employ a calx of Antimony which is not ſufficiently deprived of its phlogiſton, that we find in the crucible a button of Regulus, which being heavier than the Glaſs always lies at the bottom. With a view to avoid this inconvenience, and to diſſipate completely the exceſs of phlogiſton that may ſtill be left in the calx of Antimony; we direct the crucible to be left uncovered for ſome time at the beginning of the operation. If, notwithſtanding this precaution, any Regulus be ſtill found at the bottom of the crucible, and you reſolve to vitrify it, the crucible muſt be returned to the furnace, and the fuſion continued; by which means the Regulus will at laſt be converted into Glaſs.

If, on the contrary, you meet with any difficulty in effecting the vitrification, on account of your having employed a calx that hath loſt too much of its phlogiſton, ſuch as Diaphoretic Antimony, or the Pearly matter, the fuſion may be greatly facilitated by throwing into the crucible a little crude Antimony.

Glaſs of Antimony is a moſt violent Emetic. This Glaſs, as well as Liver of Antimony, is employed in preparing Emetic Wine and Emetic Tartar.

It may be re-ſuſcitated, like the calxes of Antimony, into a Regulus, by re-uniting it with a phlogiſton. For this purpoſe it muſt be finely pulverized, thoroughly mingled with ſome black flux, and melted in a covered crucible. This Glaſs, as well as that of Lead, hath the property of greatly promoting the vitrification of matters that are to be ſcorified.

PROCESS IX.

Kermes Mineral.

BREAK any quantity you will of Hungarian Antimony into little bits: put it into a good earthen coffee-pot: pour on it twice its weight of rain-water, and a fourth part of its weight of well filtered liquor of Nitre fixed by charcoal. Boil the whole briſkly for two hours, and then filter the liquor. As it cools it will acquire a red colour, grow turbid, and leave a red powder on the filter.

Return your Antimony into the coffee-pot. Pour on it as much rain-water as before, and three fourths of the former quantity of the liquor of Fixed Nitre. Boil it again for two hours, and then filter the liquor. It will again depoſite a red ſediment. Return your Antimony into the coffee-pot: pour on it the ſame quantity of rain-water, and half the firſt quantity of the liquor of Fixed Nitre. Boil it again for two hours, and filter the liquor as formerly. Waſh all theſe ſediments with warm water, till they become inſipid; then dry them, and you have the *Kermes Mineral.*

OBSERVATIONS.

IF you recollect what we ſaid concerning the property which Fixed Alkalis poſſeſs of uniting with Sulphur, both by fuſion, and, when thoſe Salts are reſolved into a liquor, by boiling, and of forming therewith a Liver of Sulphur, which diſſolves all metalline ſubſtances, you will readily comprehend the nature of this Kermes

Antimony conſiſts of a ſulphureous and a reguline part. Therefore, if this mineral be boiled in a ſolution of a Fixed Alkali, ſuch as Nitre fixed by charcoal, the Alkali will diſſolve the Sulphur of the Antimony, and form therewith a Liver of Sulphur; which in its turn will diſſolve the reguline part.

Now, Kermes Mineral, prepared as above directed, is no other than a Liver of Sulphur combined with a certain quantity of Regulus of Antimony.

Mr. Geoffroy hath ſet this truth in the cleareſt light, by his accurate analyſis of the Kermes Mineral. The experiments he made on that ſubject are circumſtantially related in ſeveral Memoirs printed in the volumes of the Academy for 1734 and 1735. By combining Acids with the Kermes he demonſtrated, 1. the exiſtence of Sulphur in this compound; having ſeparated from it a burning Sulphur, which cannot be miſtaken for any other than the Sulphur of Antimony. In order to obtain this Sulphur pure, an Acid muſt be employed that will not only abſorb the Alkali, but alſo perfectly diſſolve the reguline part that might otherwiſe remain united with the Sulphur. *Aqua Regia* was the Acid which ſucceeded beſt with Mr. Geoffroy. 2. He alſo proved that there is a Fixed Alkali in the compoſition of the Kermes; ſeeing the Acids with which he precipitated the Sulphur became Neutral Salts, and juſt ſuch as thoſe very Acids combined with a Fixed Alkali would have conſtituted: that is, the Vitriolic Acid produced a *Sal de duobus*; the Nitrous Acid a regenerated Nitre; and the Marine Acid a regenerated Sea-ſalt. 3. Mr. Geoffroy demonſtrated the reguline part of Antimony to be an ingredient in the Kermes; having procured therefrom an actual Regulus of Antimony, by fuſing it with the black flux.

In preparing the Kermes it is neceſſary to renew the liquor from time to time, as above directed; becauſe, when it is once impregnated with Kermes to a certain degree, it can take up no more; and conſequently the ſame liquor cannot operate again on the Antimony. Experience hath ſhewn, that, if the doſes above preſcribed be applied, the liquor will after two hours boiling be ſufficiently ſaturated with Kermes.

If the liquor in which the Kermes is diſſolved be filtered while it is very hot, and almoſt boiling, it leaves nothing on the filter; the Kermes paſſing through with it: but as it cools it grows turbid, and gradually depoſites the Kermes. Therefore it ought not to be filtered till it be cold; or, if it be filtered while it is boiling hot, in order to ſeparate from it ſome coarſe particles of Antimony not yet converted into Kermes, it muſt be filtered a ſecond time when it is cold in order to get the Kermes.

Though in the method uſually practiſed for making Kermes, the Antimony is boiled only thrice, yet it does not follow that more Kermes may not be obtained from it, or that but little more would be obtained by a fourth and fifth boiling: on the contrary it would yield conſiderably more. Mr. Geoffroy obſerved that he got more Kermes by the ſecond boiling than by the firſt, and ſtill more by the third than by the ſecond; and that the yield goes on increaſing in this manner to a very great number of times, which he hath not determined. This increaſed effect ariſes from hence, that by multiplying the frictions of the little bits of Antimony againſt each other, new ſurfaces are expoſed to the action of the Alkaline liquor, and furniſh it with more Sulphur; while the addition of this Sulphur renders the hepar more active and more penetrating; or, if you pleaſe, produces a new hepar every time the matters are boiled. When the Alkaline liquor is once ſaturated with Kermes, it ceaſes to act, and forms no new hepar; but it doth not follow that its virtue is quite exhauſted. To reſtore its ability of acting as well as at firſt, or nearly ſo, you need only let it cool, and depoſite the Kermes diſſolved in it. We owe this ſingular obſervation alſo to Mr. Geoffroy; he had the patience to go through no leſs than threeſcore and ten boilings with the ſame liquor, without adding any thing but rain water, to ſupply the place of what was diſſipated by evaporation; and he always obtained a pretty conſiderable quantity of Kermes by each boiling: nay, the yield rather increaſed each time, for the reaſon given above.

Boiling is not the only means of making Kermes. Mr. Geoffroy found the way of making it by fuſion. For this purpoſe you muſt mix accurately one part of very pure Fixed Alkali, dried and pulverized, with two parts of Hungarian Antimony alſo pulverized, and melt the mixture. Mr. Geoffroy made uſe of a retort. When the maſs is melted, it muſt again be pulverized, while it is ſtill hot, and then put into and kept in boiling-hot water for an hour or two; after which the liquor, now become ſaline and antimonial, muſt be filtered into another veſſel filled with boiling water. Every ounce of Antimony treated in this manner yields, by thrice boiling the melted maſs, from ſix drams to ſix drams and a half of Kermes; which differs from the Kermes made by boiling, only in that it is not quite ſo ſoft to the touch, having in every other reſpect the ſame qualities.

As Liver of Sulphur is made two different ways, to wit, by boiling and by fuſion, and as the Kermes is nothing but a Liver of Sulphur in which the reguline part is diſſolved; it follows that Kermes may be made by fuſion as well as by boiling. It is neceſſary to pulverize the melted maſs, and to ſteep it in boiling-hot water for an hour or two, that the water may diſſolve and divide it ſufficiently to make the Kermes fine and beautiful.

With the ſame view, that is, to make it finer and more perfect, Mr. Geoffroy orders the water ſaturated with the Kermes made by fuſion to be received, when filtered, in a veſſel full of other boiling-hot water. He obſerved that when the liquor impregnated with Kermes cools too faſt, the Kermes that precipitates is much coarſer. The warm ſolution of Kermes is diffuſed

fuſed through the boiling-hot water into which it is filtered, and thereby enabled to retain its heat ſo much the longer.

From what hath been ſaid on the nature of Kermes, it plainly appears that there muſt be a great reſemblance between it and the Golden Sulphur of Antimony, obtained from the ſcoria, either of plain Regulus of Antimony, or of the Liver of Antimony; this Golden Sulphur being no other than a portion of the Antimony combined with the Nitre alkalizated during the operation.

Yet there is a difference in the manner of precipitating theſe two compounds: for the Kermes precipitates ſpontaneouſly, on the bare cooling of the water in which it is diſſolved; whereas an Acid is employed to precipitate the Golden Sulphur ſuſpended in the water, with which the ſcoria of the plain Regulus of Antimony, or that of Liver of Antimony, hath been waſhed. This gives ſome ground to ſuſpect that the reguline part is not ſo intimately united with the Liver of Sulphur in the Kermes, as in the ſcoriæ from which the Golden Sulphur is obtained.

PROCESS X.

Regulus of Antimony diſſolved in the Mineral Acids.

COMPOUND an *Aqua Regis* by mixing together four meaſures of Spirit of Nitre, and one meaſure of Spirit of Salt: on a ſand-bath moderately heated place a matraſs, into which pour ſixteen times as much of this *Aqua Regis* as you have Regulus to diſſolve. Break your Regulus into little bits; and throw them ſucceſſively one after another into the matraſs, obſerving not to add a new one till that put in before is entirely diſſolved: continue this till your Regulus be all uſed. By degrees, as the diſſolution advances, the liquor will acquire a beautiful golden colour; which however will inſenſibly diſappear, as the white fumes that continually aſcend from it evaporate.

OBSERVATIONS.

REGULUS of Antimony is one of thoſe metalline ſubſtances that diſſolve with the greateſt difficulty. Not but that moſt of the Acids attack and corrode it; but they do not make a clear, limpid ſolution thereof: they in ſome ſort only calcine it, and this ſemi-metal, as faſt as it diſſolves, precipitates of its own accord in the form of a white magiſtery. In order to effect a complete diſſolution thereof, it is neceſſary to employ an *Aqua Regis* compounded as directed, and in the doſe preſcribed in the proceſs, which is wholly taken from Mr. Geoffroy's Memoirs on Antimony mentioned above.

If, inſtead of the Regulus, ſmall bits of crude Antimony be thrown into the *Aqua Regis*, the Acid will attack and diſſolve the reguline part, and ſo ſeparate it from the ſulphureous part which it will not touch. When the diſſolution is finiſhed, the particles of Sulphur being now become lighter, becauſe no longer united with the metalline part, will float upon the liquor. Being collected they form a true Sulphur which ſeems no way different from common brimſtone. This operation, you ſee, is a ſort of parting proceſs.

The Vitriolic Acid, whether concentrated or much weakened with water, does not act when cold either on Antimony or on its Regulus. This Acid only dims the ſplendour of the facets of the Regulus; but, if one part of exceeding pure Regulus of Antimony be put into a retort, and four parts of clear concentrated Oil of Vitriol poured on it, as ſoon as the Acid is heated it turns brown, and emits a moſt ſuffocating ſmell of Sulphur, which encreaſes as the Regulus is penetrated and corroded by the Acid.

On raiſing the fire, there ſeparates from it a matter that ſeems mucilaginous; and when the Acid hath boiled ſome time, the Regulus is converted into a white ſaline maſs, as Mercury is in the preparation of Turbith mineral. At the ſame time a little Sulphur ſublimes into the neck of the retort. At laſt all the Oil of Vitriol paſſes over into the receiver, and leaves the Regulus in a white, ſpungy, ſaline maſs in the retort. When the fire is out, the veſſels unluted, and the receiver ſeparated from the retort, there riſes a white vapour like that of the ſmoking liquor of Libavius.

The ſaline maſs left in the retort, after the operation, is found increaſed to near double its weight: this increaſed weight is owing to the Acid that hath united with the Regulus.

This combination of the Vitriolic Acid with the Regulus of Antimony is exceſſively cauſtic, and cannot, for that reaſon, be adminiſtered internally.

The pureſt Spirit of Salt hath no ſenſible effect either on Antimony or its Regulus: but if Antimony be coarſely pounded, it ſeparates therefrom, though ſlowly, ſome light, ſulphureous flakes.

The action of Spirit of Nitre on this metallic ſubſtance is more perceptible: by little and little it attacks the plates of the Antimony, which diſcharge a great number of air-bubbles. As the diſſolution advances, the Acid acquires a greeniſh colour inclining to blue; and if there be not too much of it, it will be almoſt entirely imbibed by the Antimony, penetrate between its *laminæ*, and exfoliate them in the direction of the needles that compoſe them. If there be too much of the Acid, that is, if it riſe above the Antimony, it will deſtroy theſe plates, and reduce them to a white powder.

But when the Acid is imbibed ſlowly, we diſcover between the ſwelled *laminæ* little ſaline tranſparent cryſtals, that vegetate much in the ſame manner as thoſe of the pyrites, in which ſmall cryſtals of Vitriol are frequently obſerved, whoſe figures are not very well determined. Theſe little cryſtals between the Antimonial plates are intermixed with yellow particles, which being carefully ſeparated burn like common Sulphur.

All theſe uſeful obſervations, concerning the action of the Acids on Antimony and its Regulus, we owe likewiſe to Mr. Geoffroy; who adviſes the collecting a quantity of theſe little cryſtals in time; becauſe they diſappear ſoon after they are formed, being probably covered by the white powder, or magiſtery, which is continually produced as faſt as the Nitrous Acid diſunites and ſeparates the needle-like fibres of the Antimony.

Mr. Geoffroy obſerved the ſame ſort of cryſtals on the Regulus of Antimony, when ſubſtituted for crude Antimony in this experiment: but it requires a great deal of care to ſeparate theſe cryſtals; for as ſoon as the air comes into contact with them they loſe their tranſparency; and, if you wait till the Regulus be in ſome meaſure converted into a magiſtery, they are not then to be diſtinguiſhed.

In order therefore to have a good view of theſe cryſtals, the Regulus muſt be broken to pieces; theſe pieces put in a glaſs baſon, and Spirit of Nitre poured on them to half their heighth, but not to cover them. This Acid penetrates them, exfoliates them in white ſcales; and on the ſurface of theſe ſcales the cryſtals ſhoot of a dead-white colour. In two or three days time theſe cryſtals vegetate and grow in the form of cauli-flowers: they muſt then be gathered, to prevent their being confounded in the white magiſtery which continues to be produced, and would not ſuffer them to be diſtinguiſhed. If you attempt to diſſolve the reguline part of Antimony by an *Aqua Regis* compounded in different proportions, and applied in a different doſe, from what is preſcribed in the proceſs, the Regulus of Antimony will only be calcined, as it is by the other Acids, and will precipitate in the form of a white magiſtery as faſt as it diſſolves, ſo that no part thereof will remain united with the ſolvent. The proof of this is, that, if an Alkaline liquor be poured, even to the point of ſaturation, upon the *Aqua Regis* that hath thus dropt the Antimony, no new precipitate will be depoſited.

PROCESS XI.

Regulus of Antimony combined with the Acid of Sea-ſalt. Butter of Antimony. Cinabar of Antimony.

PULVERIZE and mix thoroughly ſix parts of Regulus of Antimony, and ſixteen parts of Corroſive Sublimate. Put this mixture into a glaſs retort that hath a wide ſhort neck, and let one half of its body at leaſt be left empty. Set it in a reverberatory furnace, and having fitted a recipient thereto and luted the joint, make a very ſmall fire at firſt to heat it ſlowly. Encreaſe it afterwards by degrees, till you ſee a liquor aſcend from the retort that grows thick as it cools. Keep up the fire to this degree as long as you ſee any of this matter come over.

When no more riſes with this degree of fire, unlute your veſſels, take off the receiver, and in its place ſubſtitute another filled with water. Then encreaſe your fire by degrees till the retort be red-hot. Some running Mercury will fall into the water, which you may dry and keep for uſe; it being very pure.

OBSER-

OBSERVATIONS.

IN our obſervations on the preceding proceſs we took notice that the pureſt Marine Acid, in the form of a liquor, will not diſſolve the reguline part of Antimony. Here this very Acid combined with Mercury, and applied in a dry form to the Regulus of Antimony, quits the Mercury, with which it was united, in order to join this very Regulus, as having a greater affinity therewith. This operation is a further proof of what we advanced on the ſubject of Mercury; to wit, that ſeveral metallic ſubſtances, which are not ſoluble by certain Acids when in a fluid ſtate, may be diſſolved by thoſe very Acids when moſt highly concentrated, as they are when combined with any other ſubſtance in a dry form, and are ſeparated from it by the force of fire. Their efficacy is alſo further promoted by their being reduced, on this occaſion, into ſubtile vapours.

The Marine Acid combined with the reguline part of Antimony doth not form a hard, ſolid compound; but a kind of ſoft ſubſtance, that melts in a very gentle heat, and alſo becomes fixed by the leaſt cold, much in the ſame manner as butter; and from this property it hath its name.

Soon after mixing the Regulus with the Corroſive Sublimate, the matter ſometimes grows conſiderably hot: this is occaſioned by the Marine Acid's beginning to act on the reguline part, and to deſert its Mercury.

The Butter of Antimony riſes with a very moderate heat; becauſe the Acid of Sea-ſalt hath the property of volatilizing, and carrying up along with it, the metallic ſubſtances with which it is combined: and for this reaſon a very gentle heat only is uired at the beginning of the operation.

: is abſolutely neceſſary that the neck of the re- be wide and ſhort: for otherwiſe if the Butter of Antimony ſhould fix and be accumulated therein, it might ſtop up the paſſage entirely, and occaſion the burſting of the veſſels. By this operation we obtain eight parts and three quarters of fine Butter of Antimony, and ten parts of running Mercury; there being left in the retort one part and a half of a rarefied matter, black, white, and red. This is probably the moſt earthy and moſt impure part of the Regulus of Antimony.

It is of the utmoſt conſequence to the operator that he avoid with the greateſt care the vapours that iſſue from the veſſels, becauſe they are extremely noxious, and may occaſion mortal diſorders. The Butter of Antimony is a moſt violent Corroſive and Cauſtic.

When all the Butter is riſen, the receiver is ſhifted in order to receive the Mercury; which, being diſengaged from the Acid that gave it a ſaline form, appears in its natural form of Quick-ſilver: but it requires a much greater degree of heat than the Butter of Antimony to raiſe it by diſtillation.

If crude Antimony, inſtead of Regulus of Antimony, be mixed with Corroſive Sublimate, a Butter of Antimony will be obtained in the ſame manner; but, inſtead of having a running Mercury after the Butter, you will find a Cinabar ſublimed into the neck and upper concavity of the retort.

The reaſon of this difference is eaſily conceived: for, when the Regulus is uſed, the Mercury being deſerted by its Acid finds no other ſubſtance to unite with, and ſo riſes in the form of Quick-ſilver; but when crude Antimony is employed inſtead of its Regulus, as the reguline part thereof cannot combine with the Acid without quitting its Sulphur, ſo this Sulphur, being at liberty, unites with the Mercury, which is ſo likewiſe, and therewith forms a Cinabar; which from its origin is named *Cinabar of Antimony*. When you intend to make both

Butter and Cinabar of Antimony at the ſame time, ſix parts of Antimony muſt be mixed with eight of Corroſive Sublimate; and care muſt be taken, while the Butter is coming over, to warm the neck of the retort by holding ſome live coals near it, with the precautions neceſſary to avoid breaking it. This warmth makes the Butter melt and run into the receiver; whereas, being thicker and of a much denſer conſiſtence than that made with the Regulus, it would otherwiſe gather in the neck of the retort, choak it entirely, and burſt the veſſel.

When the Butter is drawn from crude Antimony, more circumſpection is neceſſary to make it of a beautiful white colour, than when it is obtained from the Regulus: for, if the fire be too ſtrong during the diſtillation, or if the receiver be not ſoon enough ſeparated from the neck of the retort, certain red ſulphureous vapours, the forerunners of the Cinabar, will at laſt aſcend, and mixing with the Butter give it a brown colour.

In order to reſtore its beauty it muſt be put into a clean retort, and rectified by diſtilling it over again with a gentle ſand-heat. By this rectification the Butter of Antimony becomes more fluid; and by re-diſtilling it a ſecond time you may give it the thinneſs and fluidity of an oil.

After the operation there will be found in the receiver three parts and three quarters of Butter of Antimony, and ſome ſmall cryſtals adhering to its inſide, in the form of ſprigs. When you break the retort there exhales from it a ſulphureous odour; and you will find in it ſeven parts of Cinabar of Antimony, the greateſt part of which is uſually in compact glebes, that are heavy, ſmooth, ſhining, blackiſh throughout moſt of the maſs, but in ſome places red: another part thereof appears in ſhining needles, and the reſt in powder.

When all the Butter of Antimony is come over, and you begin to ſee the red vapours that predict the approaching aſcent of the Cinabar, the receiver containing the Butter muſt be removed, leſt the colour of the Butter ſhould be ſpoiled by thoſe ſulphureous vapours. Another receiver is uſually fitted on, without luting; in which a ſmall quantity of running Mercury is ſometimes found, when the operation is finiſhed.

There remains, at the bottom of the retort, a fixed, ſhining, cryſtalline, black maſs, which may be reduced to a Regulus by the common method.

Butter of Antimony may alſo be obtained from a mixture of Antimony with any of the other preparations of Mercury in which the Acid of Sea-ſalt is an ingredient; ſuch as Sweet Sublimate, the Mercurial Panacea, and White Precipitate: but as none of theſe combinations contain ſo great a proportion of that Acid as is in the Corroſive Sublimate, the Butter obtained by their means is far from being ſo cauſtic and ſo fiery as that which riſes from a mixture of Antimony, or its Regulus, with Corroſive Sublimate.

Silver precipitated by the Acid of Sea-ſalt, and ready to be melted into a *Luna cornea*, being mixed with powdered Regulus of Antimony yields likewiſe a Butter of Antimony.

If you propoſe to make it by this means, you muſt mingle one part of the Regulus of Antimony in powder with two parts of the Precipitate; put this mixture into a glaſs retort of ſuch a ſize that it may fill but one half thereof; ſet it in a furnace; apply a receiver; begin with a gentle heat, which will make a clear liquor come over; and then encreaſe your fire by degrees. White vapours will riſe and condenſe into a liquid Butter; and in the mean time there will be a ſlight ebullition in the receiver, attended with a little heat. Continue the fire till nothing more [illegible] and white [illegible]

[illegible] Butter of [illegible] fume- [illegible] eighth part [illegible] made uſe of.

[illegible] over with [illegible] colour, and [illegible] of the retort will [illegible] ponderous maſs, diffi- [illegible] into a powder; its [illegible] and bluiſh [illegible] inter- [illegible] like Regulus of An- [illegible] a thin [illegible] on its ſurface, and [illegible] than the precipitate [illegible] the operation.

[illegible] that the Acid of [illegible] a greater affinity with Regulus of An- [illegible] Silver.

[illegible] of *Antimony* prepared by this method [illegible] than that made with Corro-ſive Sublimate. It is called the *Lunar Butter of Antimony*.

The effervescence that ariſes in the receiver is remarkable. Probably, the Acid of Sea-ſalt, though reduced into vapours when it aſcends out of the retort, is not yet perfectly combined with the reguline part of the Antimony, which it nevertheleſs carries over with it, and the union is completed in the receiver; which occaſions the efferveſcence obſerved.

The little white ſilvery flowers, adhering to the inſide of the retort, are flowers of Regulus of Antimony, which [illegible] towards the end of the diſtillation.

Th[illegible] maſs, found at the bottom of the re-[illegible] than the Silver ſeparated from its [illegible]ed with a portion of the Regulus [illegible] The colours and the ſaltiſh taſte of its ſurface are occaſioned by a remainder of the Marine Acid. This Silver is rendered brittle and eager by the union it hath contracted with ſome of the Regulus of Antimony.

It is eaſy to purify it, and reſtore its ductility, by ſeparating it from the Regulus of Antimony. There are ſeveral ways of doing this: one of the moſt expeditious is to flux it with Nitre, which burns and converts to a calx the ſemi-metal with which the Silver is adulterated.

PROCESS XII.

Butter of Antimony decompounded by means of Water only. The Pulvis Algaroth, *or* Mercurius Vitæ. *The Philoſophic Spirit of Vitriol.*

MELT with a gentle heat as much Butter of Antimony as you pleaſe. When it is melted, pour it into a large quantity of warm water. The water will immediately grow turbid, but whitiſh, and let fall a great quantity of white powder. When all the precipitate is ſettled, decant the water: pour on freſh warm water; and having thus edulcorated it by ſeveral ablutions, dry it, and you have the *Pulvis Algaroth*, or *Mercurius Vitæ*.

OBSERVATIONS.

IN the preceding proceſſes we obſerved that the Marine Acid will not diſſolve the reguline part of Antimony, unleſs it be very highly concentrated, and more ſo than it can poſſibly be while in the form of a liquor. Of this the experiment before us is a further proof. Whilſt the Marine Acid is ſo perfectly dephlegmated, as it is in Corroſive Sublimate and Butter of Antimony, it remains combined with the reguline part of Antimony; but if this combinabination be diſſolved in water, the moment the Acid is weakened by the interpoſition of the particles of water, it becomes incapable of continuing united with the ſemi-metal which it had before diſſolved; deſerts it, and lets it fall in the form of a white powder.

The *Pulvis Algaroth* is therefore no other than the reguline part of Antimony, attenuated and divided by the union it had contracted with the Acid of Sea-ſalt, and afterwards ſeparated from that Acid by the intervention of water alone. The proof is, that this powder retains none of the properties of the Butter of Antimony: it is neither ſo fuſible nor ſo volatile; on the contrary, it is capable of ſuſtaining a very ſtrong degree of fire, without ſubliming and without melting; it may be reduced to a Regulus: it hath not now the ſame cauſtic nature: it is only an emetic; which however is extremely violent, and on that account is never preſcribed by any prudent phyſician.

Another proof, that the Marine Acid is ſeparated from the Regulus of Antimony in the precipitation of the *Pulvis Algaroth*, is, that the water in which this precipitation is made becomes acid, or a ſort of weak Spirit of Salt. If it be evaporated, and concentrated by diſtillation, a very ſtrong acid liquor may be obtained from it. This Acid goes, very improperly, by the name of the *Philoſophic Spirit of Vitriol*; for it is rather a Spirit of Salt.

The *Pulvis Algaroth*, made with Butter of Antimony procured from the Regulus, is whiter than that made with Butter of Antimony procured from crude Antimony; probably becauſe the latter always retains ſome ſulphureous particles.

Butter of Antimony expoſed to the air attracts the moiſture thereof, and partly runs into a liquor; but, as faſt as this liquor is produced, it depoſites a white ſediment, which is an actual *Pulvis Algaroth*. This alſo is very agreeable to what we advanced touching the decompoſition of Butter of Antimony by the addition of water. The Butter attracts the moiſture of the air, becauſe the Acid it contains is exceedingly concentrated; and this moiſture produces the ſame effect as water purpoſely added.

PROCESS XIII.

Bezoar Mineral. The Bezoartic Spirit of Nitre.

MELT Butter of Antimony over warm aſhes, and put it into a phial or matraſs. Gradually pour on it good Spirit of Nitre, till the matter be entirely diſſolved. This uſually requires as much Spirit of Nitre as there is Butter of Antimony. Dureing the diſſolution fumes will riſe, which muſt be carefully avoided. Pour your ſolution, which will be clear and of a rediſh colour, into a glaſs cucurbit, or a pan of ſtone-ware; ſet it in a ſand-bath, and evaporate to dryneſs with a moderate heat. There will be left a white maſs, weighing a fourth part leſs than the whole quantity uſed, both of the Butter and the Spirit of Nitre. Let it cool, and again pour on it as much Spirit of Nitre as you uſed the firſt time. Place the veſſel again in the ſand-bath, and evaporate the moiſture as before. You will have a white maſs that hath neither gained nor loſt in weight. On this pour, for the third time, the ſame quantity of Spirit of Nitre as you did the firſt time. Again evaporate the moiſture to perfect dryneſs: then increaſe your fire, and calcine the matter for half an hour. You will have left a dry, friable, light, white matter, of an agreeable acid taſte; which will fall into a coarſe powder, and muſt be kept in a phial carefully ſtopt. This is *Bezoar Mineral:* it is neither cauſtic nor emetic, and has only a ſudorific virtue. It obtained the name it bears, becauſe, like the animal Bezoar, it was imagined to have the property of reſiſting poiſon.

OBSERVATIONS.

IT is not ſurprizing that the Nitrous Acid poured on Butter of Antimony ſhould diſſolve it, and unite with it: for with the Marine Acid, which makes a part of this combination, it forms an *Aqua Regis*, which we know is the true ſolvent of the reguline part of Antimony. But in this diſſolution, and the changes it produces, there are ſome things very remarkable and worthy of attention. 1. The Nitrous Acid, by uniting with the Butter of Antimony, deprives it of its property of riſing with a very gentle heat, and makes it much more fixed: it can now be dried, and ſuffer all its moiſture to be evaporated; which is not to be done with pure Butter of Antimony; for that, being expoſed to a certain degree of heat, inſtead of letting go its moiſture and remaining dry, riſes wholly, without the leaſt appearance of any ſeparation of parts.

2. The Butter of Antimony, which before its combination with the Nitrous Acid is a moſt violent Cauſtic and Corroſive, becomes ſo mild after it, that it may not only be taken internally without danger, but hath ſcarce any ſenſible operation.

The following conſiderations will lead us to a reaſonable explanation of theſe phenomena. 1. The Nitrous Acid, when combined with metallic ſubſtances, doth not communicate to them the ſame volatility as they acquire from the Marine Acid. Hence it follows that, if the Nitrous Acid be added to any combination of a metallic ſubſtance with the Marine Acid, this new compound will be rendered leſs volatile, and conſequently more able, without riſing in vapours, to bear a degree of heat ſufficient to carry off part of its Acid. This is the caſe with Butter of Antimony, after Spirit of Nitre is mixed with it: eſpecially conſidering, 2. That the Nitrous Acid cannot unite with the reguline part of the Butter of Antimony without weakening the connection between it and the Marine Acid; whence it follows that the combination of the Nitrous Acid further facilitates the ſeparation of the Marine Acid from the Regulus. Now as ſoon as the Marine Acid quits the reguline part, that part becomes more fixed, and conſequently more capable of enduring the degree of heat requiſite to diſcharge all the adhering Acid; and not only the Marine, but even the Nitrous alſo. It is not therefore ſurprizing that, after the Antimony which remains combined with the Nitrous Acid is dried, it ſhould not poſſeſs that corroſive power which it derives only from the Acids wherewith it is armed. In order to free it more perfectly from all Acid, we order the fire to be increaſed after the third deſiccation; and the remainder of the Butter of Antimony to be calcined for a full half-hour longer.

That the Marine Acid is ſeparated from the reguline part of the Butter of Antimony, by the deſiccations it undergoes in converting it into Bezoar, is proved by this, that, when theſe deſiccations are performed in cloſe veſſels, the liquor drawn off is a true *Aqua Regis*, known by the name of the *Bezoartic Spirit of Nitre.*

It remains to be conſidered why the Bezoar mineral, though freed from all Acid, is not emetic; while the *Pulvis Algaroth*, which is likewiſe the reguline part of the Butter of Antimony deprived of its Acid, is ſuch a violent emetic, and even to be dreaded for its remainder of cauſticity.

In order to diſcover the reaſon of this difference, it is proper to obſerve that, when we ſay Bezoar mineral and the *Pulvis Algaroth* contain no Acid, we muſt not be underſtood in too ſtrict a ſenſe: on the contrary, there is reaſon to think that a certain quantity of Acid ſtill remains in each of them; which however is ſcarce worth notice, in compariſon of the quantity each contained at firſt. This being allowed, it will not be difficult to find the difference between theſe two preparations of Antimony. The *Pulvis Algaroth* is deprived of its Acid by the addition of water alone, which only carries off all the looſe Acid it can take up, without making any change in the nature of that which continues in combination with the reguline part. Now, as the Marine Acid is not intimately united with the reguline part in Butter of Antimony; as it ſtill retains ſome of its properties, ſuch as attracting the moiſture of the air, giving manifeſt tokens of its Acid nature, &c; and as the corroſive quality of this compound depends on this laſt in particular; the ſmall portion of Acid left in the *Pulvis Algaroth* will in ſome degree preſerve its former character: and hence comes the effect of this powder, which ſtill retains a little of the corroſive quality that belonged to the Butter of Antimony.

But this is not the caſe with the ſmall remainder of Acid, which poſſibly ſtill continues united with the Bezoar mineral prepared as here directed. This compound hath been expoſed to a fire ſufficient, not only to dry it, but even to calcine it. Now fire is capable of producing great changes in the texture of bodies. It muſt have forced off from the Bezoar all the Acid that was not intimately combined with it; and that part which it could not drive off, becauſe of its obſtinate adheſion, it muſt have further united and combined more cloſely with the metallic earth: for we ſee that fire greatly promotes the action of ſolvents on the matters with which they are united.

With regard to the properly emetic quality of the *Pulvis Algaroth*, it cannot be imputed to the combination of any Acid with that powder; ſince we ſee that the moſt powerfully emetic preparations of Antimony, viz. its Regulus and Glaſs, contain no Acid: it muſt therefore be attributed to ſome cauſe different from that on which its corroſive quality depends. This cauſe we ſhall eaſily find by attending to the different manners in which the Marine Acid, when alone and in *Aqua Regia*, operates on the reguline part of Antimony.

The Marine Acid alone diſſolves the Regulus of Antimony, but with great difficulty; nor doth it effect a complete diſſolution thereof, as is evident from what hath been already ſaid: whereas the Marine Acid, combined with the Nitrous Acid, and therewith forming an *Aqua Regis*, as in the preparation of Bezoar, diſſolves the reguline part of Antimony completely and radically. Now, it is certain that, the more efficaciouſly Acids operate on metallic ſubſtances, the more of their phlogiſton do they deſtroy; and we cannot but recollect that the preparations of Antimony are ſo much the leſs emetic the leſs phlogiſton they contain, or the further they recede from the nature of a Regulus, and the nearer they approach to that of Diaphoretic Antimony: conſequently it is plain how Bezoar mineral, which is a ſort of calx of Antimony entirely deprived of its phlogiſton by the intimate diſſolution thereof made by the Acids of the *Aqua Regis*, may be in no degree emetic; while the *Pulvis Algaroth*, being a true Regulus of Antimony, on which the Marine Acid hath operated but very ſuperficially, and which ſtill contains a great deal of phlogiſton, is a moſt violent emetic.

PROCESS XIV.

Flowers of Antimony.

TAKE an unglazed earthen pot, having an aperture in its ſide, with a ſtopple to ſhut it cloſe. Set this pot in a furnace, the cavity whereof it may fit as exactly as poſſible; and fill up with lute the ſpace, if any, left between the veſſel and the furnace. Over this veſſel fix three aludels with a blind-head at the top; and light a fire in the furnace under the pot.

When the bottom of the pot is thoroughly red, throw into the lateral aperture a ſmall ſpoon-full of powdered Antimony. Stir the matter immediately with an iron ſpatula made a little bending, in order to ſpread it over the bottom of the veſſel, and then ſtop the hole. The flowers will riſe and adhere to the inſides of the aludels. Keep up the fire ſo that the bottom of the pot may always continue red; and, when nothing more ſublimes, put in a like quantity of Antimony, and operate as before. In this manner go on ſubliming your Antimony, till you have as many flowers as you want. Then let the fire go out; and when the veſſels are cold unlute them. You will find flowers adhering all round the inſides of the aludels and the head, which you may collect with a feather.

OBSERVATIONS.

ANTIMONY is a volatile mineral, capable of being ſublimed into flowers; but this cannot be effected without occaſioning a notable change in its parts. The reguline and the ſulphureous parts are not united ſo intimately, or in the ſame proportion, in the flowers as in the Antimony itſelf; and accordingly we find theſe flowers have a ſtrong emetic quality, which Antimony hath not. They are of divers colours; which probably ariſes from their containing more or leſs Sulphur. Three or four aludels are placed one over another, not only with a view to provide a greater ſurface to which the flowers may adhere, but alſo to give them room enough to circulate in, without which they might burſt the veſſels.

If you introduce the noſle of a pair of bellows into the pot that contains the Antimony, and blow upon it, the ſublimation of the flowers will be much ſooner accompliſhed. This is a general rule with regard to all matters that are to be ſublimed or evaporated; the reaſon of which we have already given.

It is proper that no interval be left between the furnace and the pot containing the Antimony, leſt the heat ſhould be thereby communicated to the aludels, on which the flowers faſten beſt when they are cold.

After the operation there remains at the bottom of the pot a portion of Antimony half calcined; which being pulverized, and thoroughly calcined till it emit no fume, may be employed to make the Glaſs of Antimony.

PROCESS XV.

Regulus of Antimony converted into Flowers.

PULVERIZE your Regulus of Antimony: put the powder into an unglazed earthen pot: three or four fingers breadth above the powder, fit into the pot a little cover, made of the ſame earth and having a ſmall hole in its middle, ſo that it may with eaſe be placed in the pot and taken out when there is occaſion: cover the mouth of the pot with a common lid; ſet it in a furnace, and kindle a fire under it ſufficient to make the bottom of the pot red and to melt the Regulus. When it hath been thus kept in fuſion for about an hour, let the fire go out and the whole cool. Then remove the two covers. You will find adhering to the ſurface of the Regulus, which will be in a maſs at the bottom of the pot, white flowers reſembling ſnow, intermixed with beautiful, brilliant, ſilver coloured needles. Take them out, and you will find them make about one part in ſixty two of the whole Regulus employed.

Put the covers again in their places, and proceed in the ſame manner as before: when the veſſels are cold you will find half as many more flowers as you got the firſt time.

Proceed thus till you have converted all your Regulus into flowers. This will require a conſiderable number of ſublimations, which, as you advance, will always yield you a greater portion of flowers; reſpect, however, being had to the quantity of Regulus remaining in the pot.

OBSERVATIONS.

WE muſt here repeat what we ſaid juſt before, in our obſervations on the preceding proceſs; viz. that Regulus of Antimony is capable of being wholly elevated and ſublimed by the action of fire; but that it muſt at the ſame time undergo a conſiderable change and alteration. Theſe flowers of Regulus of Antimony are very different from every other Antimonial preparation. They reſemble the Pearly matter in this, that they cannot be reduced to a Regulus by any means whatever: but they differ from it 1. in that they are not fixed; for, when melted by fire, they fly wholly away in vapours; 2. in that they are capable of being diſſolved by *Aqua Regis*, much in the ſame manner as the Regulus; whereas the Pearly matter is known to be indiſſoluble by any Acid.

As ſoon as Regulus of Antimony is in fuſion, it begins to ſublime into flowers; ſo that it is needleſs to apply a greater degree of heat than is juſt ſufficient to melt it.

A pan of ſome width is preferable to a crucible for this operation; becauſe the upper ſurface of the Regulus melted therein is larger, and, the larger that ſurface is, the more conſiderable is the quantity ſublimed from it.

The two covers which are applied within and over the pot are deſigned to check, as much as poſſible, the diſſipation of the melted Regulus; yet without abſolutely excluding the free acceſs of the air, the concourſe of which is uſeful in all metallic ſublimations. Notwithſtanding theſe precautions, it is impoſſible to prevent the eſcape of ſome of the Regulus, in vapours that cannot be confined. Somewhat leſs than three fourths of the Regulus made uſe of is nearly the yield in flowers: the reſt evaporates through the interſtices left by the covers, which muſt not be luted for the reaſon juſt aſſigned.

CHAP. II.

Of BISMUTH.

PROCESS I.

To extract Biſmuth from its Ore.

BREAK the ore of Biſmuth into ſmall pieces, and therewith fill a crucible either of earth or iron. Set the crucible in a furnace, and light ſuch a fire that the bits of ore may become moderately red. Stir the ore from time to time, and, if you perceive it crackle and fly, keep the crucible covered. At the bottom you will find a button of Biſmuth.

OBSERVATIONS.

THE extraction of Biſmuth from its ore requires nothing but ſimple fuſion, without the addition of any inflammable matter, becauſe it is naturally poſſeſſed of its metalline form. Nor does it require any flux; becauſe it is very fuſible: which allows us to melt it, and collect it in a maſs, without the neceſſity of fuſing likewiſe the earthy and ſtony matters in which it is lodged. Theſe matters remain in their firſt ſtate; and the melted Biſmuth deſcends by its gravity to the bottom of the crucible. No greater degree of heat muſt be applied, on this occaſion, than is neceſſary to melt the ſemi-metal: for, as it is volatile, part of it would be diſſipated; ſo that much leſs thereof would be obtained, if the fire were made too ſtrong, and ſo much the leſs as another portion thereof would be converted into a calx. For the ſame reaſon, the crucible muſt be taken out of the furnace as ſoon as you perceive that all the Biſmuth contained in the ore is melted, and that the button doth not increaſe.

The ore of Biſmuth may alſo be treated like the ores of Lead and Tin; that is, it may be reduced into a fine powder, mixed with the black flux, a little Borax, and Sea-ſalt; put into a cloſe crucible, and fuſed in a melting furnace. In that caſe you will find a button of Regulus covered with ſcoria. By this method rather more Biſmuth is obtained; and it is beſt to make uſe of it when the ore is poor, becauſe, in ſuch a caſe, none at all would be obtained by the other proceſs. But here care muſt be taken to apply at once the degree of fire neceſſary to melt the mixture: for, if it remain long in the fire, much Biſmuth will be loſt, on account of the great volatility of this ſemi-metal, and the facility with which it turns to a calx.

Biſmuth is pretty frequently found pure in its earthy and ſtony matrices; and, when mineralized, it is uſually ſo by Arſenic, which being ſtill more volatile flies off in vapours while the ore is melting, provided it be but in a ſmall quantity: if there be much of it, and the ore be ſmelted by fuſing it with the black flux, the Arſenic alſo is reduced to a Regulus, unites more intimately with the Biſmuth, becomes a little more fixed by that union, and increaſes the quantity of the ſemi-metallic maſs found after the fuſion.

Though Biſmuth be not uſually mineralized by Sulphur, that is not becauſe it is uncapable of uniting therewith; for, if equal parts of Biſmuth and Sulphur be melted together, after the fuſion the Biſmuth will be found encreaſed near an eighth part, and formed into a maſs diſpoſed in needles much like Antimony.

When we come to treat of the ore of Arſenic we ſhall have occaſion to ſay a good deal more concerning Biſmuth and its ore; becauſe theſe minerals reſemble each other very much.

Mr. Geoffroy, ſon of the Academician, hath ſhewn in a Memoir read before the Academy of Sciences, that there is a great reſemblance between Biſmuth and Lead. That Memoir, which contains only the beginning of Mr. Geoffroy's courſe of experiments, proves that the Author ſupports with dignity the glory of his name. It is there demonſtrated, by a very great number of experiments, that fire produces the ſame effects on Biſmuth as on Lead. This ſemi-metal is converted into a calx, into litharge, and into glaſs, as Lead is; and theſe productions have the ſame properties as the preparations of Lead made with the ſame degree of fire. Biſmuth is capable of vitrifying all the imperfect metals, and of carrying them off through the pores of the crucible. So that Gold and Silver may be purified and cupelled by its means, as well as with Lead. You may on this occaſion turn to what we have ſaid concerning Lead.

PROCESS II.

Biſmuth diſſolved by Acids. Magiſtery of Biſmuth. Sympathetic Ink.

INTO a matraſs put Biſmuth broken into little bits: pour on it, by little and little, twice as much *Aqua Fortis*. This Acid will attack the ſemi-metal briſkly, and diſſolve it entirely, with heat, effervеſcence, vapours, and puffing up. The ſolution will be clear and limpid.

OBSERVATIONS.

OF all Acids the Nitrous is that which beſt diſſolves Biſmuth. It is not neceſſary, on this occaſion, to place the phial in which the diſſolution is performed on a ſand-heat, as in moſt other metallic diſſolutions: on the contrary, care muſt be taken not to pour on all the *Aqua Fortis* at once; becauſe it operates with ſo much activity that the mixture will heave up and run over the veſſel.

The bare addition of water is ſufficient to precipitate the ſolution of Biſmuth. If this ſolution be mixed with a very large proportion of water, the liquor grows turbid, appears milky, and depoſites a precipitate of a very beautiful white. This is that White which the Ladies uſe at their toilets.

Water produces this precipitation by weakening the Acid; which probably is incapable of keeping the Biſmuth diſſolved, unleſs it have a certain degree of ſtrength.

If you would have a Magiſtery of Biſmuth beautifully white, you muſt perform the diſſolution with an *Aqua Fortis* that is not tainted with any mixture of the Vitriolic Acid; for this gives the precipitate a dirty white colour, inclining to grey. Several authors adviſe the uſe of a ſolution of Sea-ſalt, inſtead of pure water, for precipitating the Biſmuth, imagining that this Salt will effect a precipitation here as it does in the caſes of Silver and Lead. But Mr. Pott, a German Chymiſt, who hath publiſhed a long diſſertation on Biſmuth, pretends, on the contrary, that neither Sea-ſalt, nor its Acid, is capable of precipitating this ſemi-metal; and that when a precipitation takes place on mixing them with our ſolution, it is brought about only by means of the water in which thoſe ſubſtances are diffuſed.

Biſmuth may alſo be precipitated by the means of Fixed or Volatile Alkalis; but the precipitate is not of ſo fine a white as when procured by the means of pure water only.

If a greater quantity of *Aqua Fortis*, than that preſcribed in the proceſs, be made uſe of to diſſolve the Biſmuth, a great deal more water will alſo be required to precipitate the Magiſtery; becauſe there will be much more Acid to weaken. This White ought to be well waſhed, in order to free it from any remainder of acidity; and it ſhould be kept in a bottle well ſtopped; becauſe the acceſs of the air makes it turn brown, and if any of the Acid be left it will turn it yellow.

A ſolution of Biſmuth prepared with the proper quantity of *Aqua Fortis*, that is, with two parts of the Acid to one of the ſemi-metal, coaleſces into little cryſtals almoſt as ſoon as made.

Aqua Fortis not only acts on Biſmuth when ſeparated from its ore, and reduced to a Regulus, but attacks it even in its ore, and likewiſe diſſolves at the ſame time ſome portion of the ore itſelf. With this ſolution of the ore of Biſmuth Mr. Hellot makes a very curious Sympathetic Ink, differing from all that were known before.

Mr. Hellot prepares the liquor in the following manner: "He bruiſes the ore of Biſmuth to a "coarſe powder. On two ounces of this powder "he pours a mixture of five ounces of common "water with five ounces of *Aqua Fortis.* He "does not heat the veſſel till the firſt ebullitions are "over. He then ſets it in a gentle ſand-heat, and "lets it digeſt there till he ſees no more air-bubbles "riſe. When none appear in this heat, he increaſes "it ſo as to make the ſolvent boil ſlightly for a full "quarter of an hour. It takes up a tincture nearly "of the colour of brown beer. The ore that gives "the *Aqua Fortis* this colour is the beſt. He then "lets the ſolution cool, laying the matraſs on its "ſide, that he may decant the liquor more conve"niently when all is precipitated that is not "taken up by the ſolvent.

"The ſecond veſſel, into which the liquor is firſt "decanted, he alſo lays declining, that a new pre"cipitation of the undiſſolved matters may be ob"tained; after which he pours the liquor into a "third veſſel. This liquor muſt not be filtered, if "you would have the reſt of the proceſs ſucceed "perfectly; becauſe the *Aqua Fortis* would diſſolve "ſome of the paper, and that would ſpoil the co"lour of your liquor.

"When this ſolution, which Mr. Hellot calls the "*impregnation*, is thoroughly clarified by being "decanted three or four times, he puts it into a "glaſs baſon with two ounces of very pure Sea"ſalt. The fine white ſalt made by the ſun ſuc"ceeded beſt with Mr. Hellot. If that cannot be "had, common bay-ſalt, purified by ſolution, fil"tration, and cryſtallization, may be uſed inſtead "of it. But as it is rare to meet with any of the "ſort that is not a little tainted with iron, the white "bay-ſalt is to be preferred. The glaſs baſon he "ſets in a gentle ſand-heat, and keeps it there till

" the mixture be reduced by evaporation to an al-
" moſt dry ſaline maſs.

" If you deſire to ſave the *Aqua Regis*, the im-
" pregnation muſt be put into a retort, and diſtilled
" with the gentle heat of a ſand-bath. But there
" is an inconvenience, as Mr. Hellot obſerves, in
" employing a retort; which is, that, as the ſaline
" maſs cannot be ſtirred while it coagulates in the
" retort, it is reduced to a compact cake of colour-
" ed Salt, which preſents but one ſingle ſurface to
" the water in which it muſt be diſſolved; ſo that
" the diſſolution thereof takes up ſometimes no leſs
" than five or ſix days. In the baſon, on the con-
" trary, the ſaline maſs is eaſily brought to a gra-
" nulated Salt, by ſtirring it with a glaſs rod; and,
" when thus granulated, it has a great deal more
" ſurface; it diſſolves more eaſily, and yields its
" tincture to water in four hours time. Indeed one
" is more expoſed to the vapours of the ſolvent,
" which would be dangerous, if the operation were
" to be often performed, without proper precau-
" tions.

" When the baſon, or little veſſel, containing
" the mixture of the impregnation and Sea-ſalt
" is heated, the liquor, which was of an orange
" coloured red, becomes a crimſon red; and, when
" all the phlegm of the ſolvent is evaporated, it ac-
" quires a beautiful emerald colour. By degrees it
" thickens, and turns of the colour of a maſs of
" Verdegris. It muſt then be carefully ſtirred with
" the glaſs rod, in order to granulate the Salt,
" which muſt not be kept over the fire till it be
" perfectly dry; becauſe you run a riſk of loſing
" irrecoverably the colour you are ſeeking. You
" may be ſure you have loſt it, if by too much
" heat the Salt that was of a green colour turn
" to a dirty yellow. If it be once brought to this
" ſtate, it will continue without changing when

“cold: but if care be taken to remove it from the fire while it is ſtill green, you will ſee it gradually grow pale, and become of a beautiful roſe colour as it cools.

“Mr. Hellot ſeparates it from this veſſel, and throws it into another containing diſtilled rain water: and this ſecond veſſel he keeps in gentle digeſtion till he obſerves that the powder which falls to the bottom is perfectly white. If, after three or four hours digeſting, this powder ſtill continues tinged with a roſe colour, it is a proof that water enough was not added to diſſolve all the Salt impregnated with the tincture of the ſolution. In this caſe, the firſt tinged liquor muſt be poured off, and freſh water added in proportion to the quantity of tinged Salt that is ſuppoſed to remain mixed with the precipitate.

“When the ore is pure, and doth not contain a great deal of fuſible ſtone, commonly called *Fluor* or *Quartz*, an ounce of it generally yields tincture enough for eight or nine ounces of water, and the liquor is of a beautiful colour, like that of the lilach or pipe-tree bloſſom. In order to prove the effect of this tincture, you muſt write with this lilach-coloured liquor on good well gummed paper, that does not ſink: or you may uſe it to ſhade the leaves of ſome tree or plant, having firſt drawn the outlines thereof lightly with China-ink or with a black-lead pencil. Let this coloured drawing, or writing, dry in a warm air. You will perceive no colour while it is cold; but, if it be gently warmed before the fire, you will ſee the writing, or the drawing, gradually acquire a blue or greeniſh-blue colour, which is viſible as long as the paper continues a little warm, and diſappears entirely when it cools.”

The ſingularity of this ſympathetic ink conſiſts in its property of diſappearing entirely and becoming inviſible, though it be not touched with any thing whatever: and this diſtinguiſhes it from all others; which, when once rendered viſible by the application of proper means, do not again diſappear, or at leaſt not without touching the ſtrokes on the paper with ſome other liquor.

Mr. Hellot made a vaſt variety of experiments on this ſubject, and gave his ſympathetic ink ſucceſſively the properties of all others that are known.

It follows from Mr. Hellot's experiments that it is the Acid of Sea-ſalt which makes this ſaline *magma* of a green colour while it is hot; that without this Acid the ſaline matter continues red; and that the ſolution of Biſmuth-ore in *Aqua Fortis* may therefore ſerve as a touchſtone, to diſcover whether or no any unknown Salt under examination contains Sea-ſalt, or a portion of the Marine Acid.

He alſo proves, in the Memoirs he hath given in on this ſubject, that the Nitrous Acid is the true ſolvent of thoſe ores of Biſmuth which contain moreover Smalt and Arſenic. That Acid diſſolves all the metallic and colouring matters contained in thoſe ores, ſparing nothing but the ſulphureous and arſenical portion, the greateſt part of which remains precipitated; and from this colouring matter the ſympathetic ink derives its virtue.

Under the head of Arſenic we ſhall ſpeak more amply of this matter in Cobalt, or ore of Arſenic, that gives a blue colour to the ſand with which it is vitrified.

The Vitriolic Acid doth not, properly ſpeaking, diſſolve Biſmuth. If to one part and an half of this ſemi-metal you add one part of Oil of Vitriol; diſtill the whole to dryneſs; and then lixiviate with water what remains in the retort; the liquor you obtain by this means will be of a rediſh yellow colour, but will let nothing fall when mixed with an Alkali: and this ſhews that the Vitriolic

Acid acts only upon the inflammable part of Biſmuth, and doth not diſſolve its metallic earth.

It diſſolves the ore of Biſmuth more perceptibly than Biſmuth itſelf; becauſe the ore contains, beſides the reguline part, an arſenical matter, and a coloured matter, over which perhaps it hath more power.

The Acid of Sea-ſalt attacks and diſſolves Biſmuth in ſome ſmall meaſure, but ſlowly and with difficulty. That this Acid diſſolves a portion of our ſemi-metal may be proved, by mixing a Fixed or Volatile Alkali with Spirit of Salt in which Biſmuth hath lain ſome time digeſting; for then a precipitate falls.

But, though the Marine Acid be capable of diſſolving Biſmuth, it doth not follow that it hath a greater affinity than the Nitrous Acid with this metallic ſubſtance, as ſome Chymiſts have thought; who imagined that, in the precipitation of the Magiſtery of Biſmuth by a ſolution of Sea-ſalt, the Acid of that Salt quits its baſis to unite with the Biſmuth which it precipitates, as is the caſe in the precipitations of Lead and of Silver by the ſame Salt, and that it forms, on this occaſion, a *Biſmuthum corneum*.

On this ſubject Mr. Pott obſerved, 1. that, when only a ſmall quantity of the ſolution of Sea-ſalt is mixed with the ſolution of Biſmuth in the Nitrous Acid, no precipitate is formed: now it is certain that when the ſmalleſt quantity whatever of Sea-ſalt is mixed with the ſolution either of Lead or of Silver, a precipitate is immediately depoſited, in a quantity proportioned to that of the Salt uſed.

2. Mr. Pott, having examined the precipitate of Biſmuth thrown down by a ſolution of Sea-ſalt, found it not to have the properties of a metallic ſubſtance rendered horny: on the contrary, that precipitate being expoſed to a very violent fire appeared refractory, and could not be melted.

CHAP. III.

Of ZINC.

PROCESS I.

To extract Zinc from its ore, or from Calamine.

TAKE eight parts of Calamine reduced to a powder; mix this powder accurately with one part of fine charcoal-duſt, previouſly calcined in a crucible to free it from all moiſture: put this mixture into a ſtone retort coated with lute, leaving a third part of it empty: ſet your retort in a reverberatory furnace, capable of giving a very fierce heat. To the retort apply a receiver, with a little water in it. Kindle the fire, and raiſe it by degrees till the heat be ſtrong enough to melt copper. With this degree of fire the Zinc being metallized will ſeparate from the mixture, and ſublime into the neck of the retort, in the form of metallic drops. Break the retort when it is cold, and collect the Zinc.

OBSERVATIONS.

THE proceſs here given for ſmelting Zinc out of Calamine is taken from the Memoirs of the Academy of Sciences at Berlin. The author of it is Mr. Marggraff, a ſkilful Chymiſt, whom we have already had occaſion to mention under the article of Phoſphorus.

Till this proceſs was publiſhed, we knew no method of obtaining pure Zinc directly from the *Lapis Calaminaris*.

Moſt of the Zinc we have comes from an ore of difficult fuſion that is worked at Goſlar, and yields, at one and the ſame time, Lead, Zinc, and another metallic matter called *Cadmia Fornacum*, which alſo contains much Zinc, as we ſhall afterwards ſee.

The furnace uſed for ſmelting this ore is cloſed on its fore-ſide with thin plates or tables of ſtone, not above an inch thick. This ſtone is greyiſh, and bears a violent fire.

In this furnace the ore is melted amidſt charcoal, by the help of bellows. Each melting takes twelve hours, during which time the Zinc flowing with the Lead is reſolved into flowers and vapours, great part of which adheres to the ſides of the furnace in the form of a very hard cruſt of earth. The workmen take care to remove this cruſt from time to time; for it would otherwiſe grow ſo thick at laſt as to leſſen the cavity of the furnace very conſiderably.

There adheres moreover to the fore-part of the furnace, which is formed, as we ſaid before, of thin plates of ſtone, a metallic matter, which is the Zinc, and is carefully collected at the end of each melting, by removing from this part all the live coals. A quantity of ſmall-coal is laid unlighted at the bottom; and on this ſmall-coal, by ſtriking the ſtone plates gently with a hammer, the Zinc is made to fall out of the other matter, known by the Latin name of *Cadmia Fornacum*, among which it appears fixed in a radiated form. To this other matter we may properly enough give the name of *Furnace-Calamine*. The Zinc falls in the form of a melted metal, all on fire, and in a bright flame. It would ſoon be entirely burnt and reduced to flowers, as we ſhall ſee, if it were not extinguiſhed, and eaſily cooled and fixed, by being hid under the unlighted ſmall-coal placed below on purpoſe to receive it.

The Zinc adheres to the fore-part of the furnace preferably to any other, becauſe that being the thinneſt is therefore the cooleſt: and, in order further to promote its fixing on this part, they take care to keep the thin ſtone plates cool during the operation, by throwing water on them.

Hence it appears that Zinc is not extracted from its ore by fuſion and the precipitation of a Regulus, like other metallic ſubſtances. This is owing to the great volatility of our ſemi-metal, which cannot, without ſubliming, bear the degree of fire neceſſary to melt its ore. It is at the ſame time ſo combuſtible, that a great part of it riſes in flowers which have not the metalline form.

Mr. Marggraff provides againſt theſe inconveniences by working the ore of Zinc in cloſe veſſels. By this means he prevents the Zinc from taking fire, and being converted into flowers; ſo that it ſublimes in its metalline form. The water in the recipient ſerves to receive and cool the drops of Zinc that may be forced quite over the helm. As the operation requires a moſt violent fire, theſe drops muſt needs iſſue exceeding hot, and, without this precaution, break the recipient.

Mr. Marggraff by the ſame proceſs extracted Zinc out of the Furnace-Calamine procured from ores containing Zinc; from Tutty, which is a ſort of furnace calamine; from the flowers and from the calx of Zinc; and from the precipitate of White Vitriol; all of them matters known to be Zinc, that wanted nothing but the philogiſton to give it a ſemi-metalline form, and from which nevertheleſs no body could ever before him procure any Zinc.

Mr. Marggraff obſerves, that the Zinc obtained by his proceſs bears being flatted under the hammer into pretty thin plates; which the common Zinc will not do. The cauſe of this probably is, that the Zinc obtained by his method is more intimately combined with the phlogiſton, and contains a greater quantity thereof, than that which is procured in the ordinary way.

PROCESS II.

To ſublime Zinc into Flowers.

TAKE a very deep, large crucible: place this crucible in a furnace, ſo that it may ſtand inclining in an angle of forty-five degrees nearly. Throw ſome Zinc into it, and kindle a fire in the furnace ſomewhat ſtronger than would be neceſſary to keep Lead in fuſion. The Zinc will melt. Stir it with an iron wire, and there will appear on its ſurface a very bright white flame: two inches above this flame a thick ſmoke will be formed, and with this ſmoke exceeding white Flowers will riſe, and remain ſome time adhering to the ſides of the crucible, in the form of a very fine light down. When the flame ſlackens, ſtir your melted matter again with the iron wire: you will ſee the flame renewed, and the Flowers begin again to appear in greater abundance. Go on thus till you obſerve that the matter will not flame, nor any more Flowers riſe.

OBSERVATIONS.

ZINC takes fire very eaſily as ſoon as it is affected by a certain degree of heat; which proves that in the compoſition of this ſemi-metal there is very much phlogiſton, united but ſlightly with its metallic earth. The Flowers into which Zinc reſolves, during its combuſtion, are of a perfectly ſingular nature, and differ greatly from all the other productions obtainable out of metallic ſubſtances.

They may be conſidered as the very calx of Zinc, or its metallic earth robbed of its phlogiſton, and ſublimed during the combuſtion of this ſemi-metal, being probably carried up by the phlogiſton in flying off. For theſe Flowers, when once ſublimed, are afterwards exceedingly fixed: they ſuſtain the greateſt violence of fire without riſing, and are converted by it into a ſort of glaſs.

None of the methods hitherto employed, for reſtoring to the Flowers of Zinc their metalline form, have ever ſucceeded. When treated like other metalline calxes in a crucible, with every kind of inflammable matter, and different ſorts of reducing fluxes, they never can be re-metallized: they only melt with the flux, and produce a kind of Glaſs.

Mr. Marggraff indeed, as mentioned before, obtained Zinc from theſe Flowers, by treating them as he did Calamine in a retort with charcoal-duſt: but as the Flowers often carry up with them little particles of undecompoſed Zinc, there ſtill remains ſome doubt concerning the reduction of theſe Flowers, even by this method.

If the crucible, into which you put the Zinc to be converted into Flowers, inſtead of being left open, as directed, be covered with another crucible inverted, the two veſſels luted together, placed in a melting furnace, and a ſtrong fire immediately kindled and kept up for about half an hour; you will find, when the veſſels are cold, that all the Zinc hath left the lower crucible, and is ſublimed into the upper one, in its metalline form, without ſuffering any decompoſition. This experiment proves that Zinc, to be converted into Flowers, muſt neceſſarily be ſet on fire and burnt. As it cannot burn in cloſe veſſels, any more than other combuſtible bodies, and as it is volatile, it ſublimes without ſuffering any decompoſition. Regulus of Antimony and Biſmuth may be ſublimed in the ſame manner;

but not ſo eaſily as Zinc, which is ſtill more volatile than thoſe other ſemi-metals.

It is neceſſary to ſtir the Zinc in fuſion from time to time with an iron wire, when you intend to convert it into Flowers: for there forms on its ſurface a grey cruſt that obſtructs its deflagration, and beneath which it is gradually converted into a clotted calx. In order, therefore, to promote the riſing of the Flowers, care muſt be taken to break this cruſt, as oft as it begins to form. On this there immediately appears a very bright white flame: two inches above the flame is ſeen a thick ſmoke, and with this ſmoke very white Flowers riſe, that continue ſome time adhering to the inſide of the crucible, in the form of a fine down.

M. Malouin, who, in ſundry Memoirs on Zinc, hath endeavoured to diſcover what reſemblance there is between this ſemi-metal and Tin, tried to calcine Zinc in the ſame manner as Tin; but found it ſomewhat more difficult. Zinc, while it is not in fuſion, doth not calcine; but it begins to turn to a calx the moment it begins to melt. M. Malouin, having repeated the fuſion of Zinc a great number of times, by that means collected at laſt a quantity of the calx of this ſemi-metal, reſembling other metalline calxes. This calx of Zinc he melted in a crucible with animal fat; whereby the calx was remetallized, and reduced to Zinc. There is great reaſon to believe that the calx of Zinc made by this method is not ſo much burnt as the Flowers, and that it ſtill contains a portion of phlogiſton.

PRO-

PROCESS III.

To combine Zinc with Copper. Braſs. Prince's Metal, &c.

POUND one part and an half of Calamine, and an equal quantity of charcoal: mingle theſe two powders together, and moiſten them with a little water. Put this mixture into a large crucible, or ſome other earthen veſſel that will bear a melting heat. Amongſt and over this mixture put one part of very pure Copper in thin plates, and then put freſh charcoal-duſt over all: cloſe the crucible; ſet it in a melting furnace; put coals all round it, and let them kindle gradually. Raiſe the fire ſo as to make the crucible very red hot. When you obſerve that the flame hath acquired a purple or blueiſh-green colour, uncover the crucible, and dip into it an iron wire, to examine whether or no the copper be in fuſion under the charcoal-duſt. If you find it is, moderate the force of the fire a little, and let your crucible remain in the furnace for a few minutes. Then take it out and let it cool: you will find your Copper of a gold colour, increaſed in weight a fourth, or perhaps a third part, and yet very malleable.

OBSERVATIONS.

THE *Lapis Calaminaris* is not the only ſubſtance with which Copper may be converted into Braſs: all other ores containing Zinc, the Furnace-Calamine that ſublimes where ſuch ores are worked, Tutty, Zinc in ſubſtance, may be ſubſtituted for it, and, like it, will make very fine Braſs; but, in order to ſucceed, ſundry precautions are neceſſary which we ſhall now lay before you.

This proceſs is a ſort of cementation: for the Calamine doth not melt; only the Zinc is converted into vapours, and then combines with the Copper. On this the ſuccefs of the operation partly depends, as it is the means of the Copper's preſerving its purity and malleability; becauſe the other metallic ſubſtances that may be united with the ore of Zinc, or with the Zinc itſelf, not having the ſame volatility, cannot be reduced to vapours. If you are appriſed that the Calamine, or other ore of Zinc uſed on this occaſion, is contaminated with a mixture of any other metallic matter, you muſt mingle luting earth with the charcoal-duſt and the matter containing the Zinc; make it into a ſtiff paſte with water; of thls make a bed at the bottom of your crucible, and ram it hard down; lay the Copper plates thereon, cover them with charcoal-duſt, and then proceed as before. By this means when the Copper melts it cannot fall to the bottom of the crucible, nor mix with the ore; but is borne up by the mixture, and cannot combine with any thing but the Zinc, that riſes in vapours, and, paſſing through the lute, fixes in the Copper.

Lapis Calaminaris, or other ore of Zinc, may alſo be purified before it be uſed for making Braſs; eſpecially if adulterated with Lead ore, which is often the caſe. For this purpoſe the ore muſt be roaſted in a fire ſtrong enough to give a ſmall degree of fuſion to the leaden matter; which will thereby be reduced into larger, heavier, and tougher maſſes. The moſt ſubtile particles are diſſipated in the torrefaction, together with ſome of the Calamine. The Calamine, on the contrary, is by roaſting made more tender, lighter, and much more friable. When it is in this condition, put it into a waſhing tray or fan; dip the tray in a veſſel full of water, and bruiſe the matter it contains. The water will carry off the lighteſt powder, which is the Calamine, and leave nothing at the bottom of the tray but the heavieſt ſubſtance; that is, the leaden matter, which is to be rejected as uſeleſs. The powder of the Calamine will ſettle at the bottom of the veſſel, where, after pouring off the water, it may be found, and uſed as above directed.

In this operation the charcoal-duſt ſerves to prevent both the Copper and the Zinc from being calcined: and for this reaſon, when you work on a great quantity of materials at once, it is not neceſſary to uſe ſo much charcoal-duſt, in proportion, as when you work but on a ſmall quantity; becauſe, the greater the maſs of metal, the leſs eaſily will it calcine.

Though the Copper melts in this operation, yet it is far from being neceſſary to apply ſuch a ſtrong fire as Copper uſually requires to melt it: for the acceſſion of the Zinc, on this occaſion, communicates to it a great degree of fuſibility. The encreaſe of its weight is alſo owing to the quantity of Zinc combined with it. Copper acquires ſtill another advantage by its aſſociation with this ſemi-metal; for it remains longer in the fire without calcining.

Braſs well prepared ought to be malleable when cold. But in whatever manner it be made, and whatever proportion of Zinc there be in it, it is conſtantly found quite unmalleable when red-hot.

Braſs melted in a crucible, with a fierce heat, takes fire almoſt like Zinc, and from its ſurface many white flowers aſcend, dancing about in flakes like the flowers of Zinc. They are indeed the flowers of Zinc, and the flame of Braſs urged by a ſtrong fire is no other than the flame of the Zinc that is united with the Copper, and then burns. If Braſs be thus kept long in fuſion it will loſe almoſt all the Zinc it contains. It will alſo loſe much of its weight, and its colour will be nearly that of Copper. It is therefore neceſſary, towards performing this operation aright, to ſeize the moment when the Copper is ſufficiently impregnated with

Zinc, when it hath acquired the moſt weight and the fineſt colour, with the leaſt detriment to its ductility, that is poſſible, and that inſtant to put out the fire; becauſe, if the Copper be left longer in fuſion, it will only loſe the Zinc already united with it. Skill acquired by much practice, and an acquaintance with the particular Calamine employed, are neceſſary to guide the Artiſt ſurely through this operation; for there are very conſiderable differences between the ſundry ores of Zinc. Some of them contain Lead, as was ſaid above, and in others there is Iron. When theſe heterogeneous metals come to be mixed with the Copper, they do indeed augment its weight, but they render it at the ſame time pale, and make it very harſh. Some Calamines require to be roaſted before they can be uſed for this purpoſe, and in the torrefaction emit vapours of a Volatile Alkali, ſucceeded by vapours of a Sulphureous Spirit: others exhale no vapours while roaſting, and may be employed without any antecedent preparation. Theſe different qualities muſt evidently produce great differences in the operation.

Braſs may alſo be made, as Prince's metal and other imitations of Gold are actually made, by uſing Zinc in ſubſtance, inſtead of the ores that contain it. But theſe compoſitions have not, when cold, the ductility of Braſs prepared with *Lapis Calaminaris*, becauſe Zinc is ſeldom pure, or free from a mixture of Lead. Perhaps alſo the different manner in which the Zinc unites with the Copper may contribute to this variation.

To obviate this inconvenience, the Zinc muſt be refined from all alloy of Lead. The property of being indiſſoluble by Sulphur, which this ſemi-metal poſſeſſes, points out a very practicable method of doing it. The Zinc muſt be melted in a crucible, and ſtirred briſkly with a ſtrong iron wire, while tallow and mineral Sulphur are alternately projected upon it; but ſo that the quantity of Sulphur may greatly exceed that of the tallow. If the Sulphur do not burn entirely away, but form a kind of ſcoria on the ſurface of the Zinc, it is a ſign that your ſemi-metal contains Lead. In this caſe you muſt continue throwing in more Sulphur, and keep ſtirring the Zinc inceſſantly, till you perceive that the Sulphur ceaſes to unite any more with a metallic ſubſtance, but burns freely on the ſurface of the Zinc. The ſemi-metal is then refined; becauſe the Sulphur, which cannot diſſolve it, unites very readily with the Lead, or other metallic ſubſtance, contained in it.

If Zinc thus refined be mixed with pure Copper, in the proportion of a fourth or a third part, and the mixture be kept in fuſion and conſtantly ſtirring for ſome time, the Braſs produced will be as ductile, when cold, as that made by cementation with the *Lapis Calaminaris*.

With regard to Prince's metal, and other imitations of Gold, they are made either with Copper or Braſs re-combined with more Zinc. As it is neceſſary, for giving them a fine golden colour, to mix with them other proportions of Zinc than that required to make Braſs only, they are generally much leſs ductile. In 1725 M. Geoffroy gave a Memoir on this ſubject, in which he examined the effects of incorporating both Copper and Braſs with Zinc, from a ſmall to a very large quantity.

PROCESS IV.

Zinc diſſolved in the Mineral Acids.

WEAKEN concentrated Oil of Vitriol by mixing with it an equal quantity of water. Into a matraſs put the Zinc you intend to diſſolve, firſt broken to ſmall pieces. Pour on it ſix times its weight of the Vitriolic Acid, lowered as above directed, and let the matraſs in a ſand-bath gently heated. The Zinc will diſſolve entirely, without any ſediment. The Neutral Metallic Salt reſulting from this diſſolution ſhoots into cryſtals, which go by the name of *White Vitriol*, or *Vitriol of Zinc*.

OBSERVATIONS.

THOUGH Zinc be ſoluble in all the Acids, and when combined with thoſe Acids exhibits ſome uncommon phenomena, yet M. Hellot is the firſt that ever gave a particular account of what happens in thoſe diſſolutions: ſo that all we have to ſay on this head is extracted from that Gentleman's Memoirs. If a ſolution of Zinc in the Vitriolic Acid, prepared according to the directions in the proceſs, be diſtilled from a retort placed in a ſand-bath with a graduated heat, almoſt half the liquor preſently comes over in pure phlegm. A ſmall quantity of a Sulphureous Acid Spirit riſes next. A greater force of fire is now requiſite: the retort muſt therefore be removed into a reverberatory, and the diſtillation continued with a naked fire. On the firſt impreſſion of this heat an odour of Liver of Sulphur diſcovers itſelf, which becomes ſharp and ſuffocating towards the end of the diſtillation. In two hours time white vapours begin to appear, as in the rectification of common Oil of Vitriol. If the Receiver be then ſhifted, you will obtain an Oil of Vitriol, in quantity about the eighteenth part of the whole uſed in the diſtillation, which, though ſulphureous, is yet ſo concentrated, that, if a few drops thereof be poured into a weak Oil of Vitriol, they fall to the bottom with as much noiſe as if they were ſo many bits of red-hot iron, and heat this Oil of Vitriol as much as common Oil of Vitriol heats water.

At the bottom of the retort there remains a dry, white, cryſtalline, ſaline maſs, exceeding, in weight, the Zinc that was diſſolved, about a twelfth part of the whole weight of the liquor. The encreaſe of its weight is owing to a portion of the Vitriolic Acid that remains concentrated in the Zinc, and could not be expelled by the fire. This portion of Acid adheres to it moſt tenaciouſly: for, though M. Hellot kept the retort containing it during two whole hours in ſo violent a fire that the veſſel began to melt, the ſmalleſt vapour did not riſe from it.

This ſaline *Caput mortuum* is in the form of needles, much like the Sedative Salt. It is cauſtic, grows conſiderably hot when water is poured on it, and gives in the air, but ſlowly. Spirit of Wine, digeſted with this Salt for eight or ten days, acquires the ſame ſmell as that which is mixed with concentrated Oil of Vitriol in preparing Æther.

Zinc is diſſolved by the Nitrous and Marine Acids, much in the ſame manner as by the Vitriolic; except that the Marine Acid does not touch a black, ſpungy, rarefied matter, which it ſeparates from the Zinc. M. Hellot found upon trial that this matter is not Mercury, and that it cannot be reduced to a metallic ſubſtance.

That ingenious Chymiſt diſtilled likewiſe Solutions of Zinc in the Nitrous and Marine Acids. There came over at firſt, as there did from the ſolution made by the Vitriolic Acid, an aqueous, and then an acidulated liquor. At laſt, by exciting the fire with great violence, towards the end of the diſtillation, he obtained a ſmall quantity of the Acid that had been employed in the diſſolution: but the ſmall portion of Acid thus obtained was exceeding ſtrong; and the quantity of the Nitrous much more conſiderable than that of the Marine Acid.

A ſolution of Zinc in the Marine Acid, being diſtilled to dryneſs, yields a Sublimate on applying a violent heat to it.

All the Acids diſſolve with eaſe, not only Zinc, but its Flowers alſo; and that nearly in the ſame quantity, and with almoſt all the ſame phenomena. Mr. Hellot, obſerving that the reſidues of moſt of the ſolutions of Zinc have a great reſemblance with its Flowers, is of opinion that this ſemi-metal may be reduced, by the means of ſolvents, to the ſame ſtate into which it is brought by the fire when ſublimed in Flowers.

CHAP. IV.

Of ARSENIC.

PROCESS I.

To extract Arſenic from its Matrices. Zafre or Smalt.

POWDER ſome Cobalt, white Pyrites, or other Arſenical matters. Put this powder into a retort with a ſhort wide neck, leaving a full third thereof empty. Set your retort in a reverberating furnace; lute on a receiver; heat your veſſel by degrees, and increaſe the fire till you ſee a powder ſublime into the neck of the retort. Keep up the fire in this degree as long as the ſublimation continues: when this begins to ſlacken, raiſe your fire, and make it as ſtrong as the veſſels will bear. When nothing more aſcends, let it go out. On unluting the veſſels, you will find in the receiver a little Arſenic in the form of a fine light *farina*. The neck of the retort will be full of white flowers, not quite ſo fine, ſome of which will appear like little cryſtals; and if a good deal of Arſenic be ſublimed, a ponderous matter, like a white, ſemi-tranſparent glaſs, will be found adhering to that part of the neck of the retort which is next its body.

OBSERVATIONS.

ARSENIC is a metallic ſubſtance ſtill more volatile than Zinc; ſo that it cannot be ſeparated from the matters with which it is mixed otherwiſe than by ſublimation. It is proper, however, to take notice that it is not naturally in a metallic form, and that, properly ſpeaking, the whole Sublimate obtained from Cobalt, as above directed, is nothing but a metallic calx, that cannot be brought to the form and gloſs of a metal, till it be worked up with fatty matters, as we ſhall ſhew in its place.

This calx is of a very ſingular nature, and differs from every other metallic calx, in that this is volatile, and all the reſt extremely fixed; even thoſe procured from the ſemi-metals: for the Flowers of Zinc, which are juſtly conſidered as a calcined Zinc, tho' obtained by a ſort of ſublimation, are not for all that of a volatile nature, but rather exceedingly fixed; ſeeing they are capable of ſuſtaining the moſt violent fire, and melt inſtead of ſubliming. Arſenic, on the contrary, is not only extracted from its ore by ſublimation, but when once ſublimed continues to be volatile, and flies off in vapours as ſoon as it is expoſed even to a moderate degree of heat.

This metallic matter, before it is conbined with the Phlogiſton, is called *White Arſenic*, or plain *Arſenic*: it acquires the title of *Regulus of Arſenic* when it is united with the Phlogiſton, and glitters like a metal.

Though Arſenic be volatile, yet it requires a pretty ſtrong fire to ſeparate it from the minerals containing it, eſpecially in cloſe veſſels; becauſe it adheres very cloſe to earthy and vitrifiable matters. This adheſion is ſo firm, that, when thus combined, it is capable of bearing a melting heat, and vitrifies with metallic calxes, and other fuſible matters. On this account it is impoſſible to extract from Cobalt, or other Arſenical matters, all the Arſenic they contain by working them only in cloſe veſſels. If ſuch matters are to be freed from all their Arſenic, you muſt, after you have extracted all they will yield by diſtillation, put them into a crucible, and ſet it uncovered in the midſt of a ſtrong fire. Many Arſenical vapours will ſtill riſe; and care muſt be taken to ſtir the contents of the crucible frequently with an iron rod, to facilitate the diſcharge of the remaining Arſenic.

It often happens that the Arſenic, obtained from minerals by ſublimation, is not very white, but of a lighter or darker grey colour. This is owing to ſome parcicles of inflammable matter, from which Arſenical minerals are ſeldom quite free. A very ſmall quantity of phlogiſton is ſufficient to deprive much Arſenic of its whiteneſs, and to give it a grey colour. But when fouled in this manner, it may eaſily be brought to its due degree of whiteneſs: it need only be ſublimed once more, after mixing it with ſome ſubſtance on which it doth not act; Sea-ſalt, for inſtance. If the matters from which Arſenic is extracted contain Sulphur alſo, as ſome pyrites do, the Arſenic ſublimes with much leſs heat, than when it is united with earthy matters only; becauſe it combines with the Sulphur, wherewith it hath a great affinity, and the Sulphur ſerves to ſeparate the Arſenic, by this interpoſition, from the earth. In conſequence hereof, Sulphur may be employed to extract Arſenic out of the earths in which it is fixed. In this caſe, the Sulphur changes the colour of the Arſenic, which it makes of a lighter or deeper yellow, or even red, in proportion to the quantity there is of it, and to the degree of fire that hath acted on both together.

The conſiſtence of Arſenic is different, according to the degree of heat applyed in ſubliming it. If the Arſenical vapour meet with a cold place, it gathers there in the form of a powder, as the Flowers of Sulphur do: this is the caſe with that which falls into the receiver in diſtilling it. But, if it be ſtopped in a hot place, and cannot eſcape from that heat, it condenſes into a heavy, compact, ſemi-tranſparent body, having undergone the firſt degree of fuſion.

Yet it cannot be perfectly melted, ſo as to flow like other fuſed matters: not that it is refractory; for, on the contrary, the degree of heat in which it begins to melt is very moderate, and it is in its own nature very fit to promote the fuſion of refractory matters: but the reaſon is this; it is neceſſarily converted into vapours by the degree of heat neceſſary to fuſe it, and theſe vapours burſt the veſſels, if they find no vent.

Arſenic made yellow by a mixture of Sulphur, which is alſo called *Orpiment*, is reducible to the form of a ſolid Sublimate with more eaſe; becauſe it is alloyed with a twentieth, or perhaps a tenth part, of its weight of Sulphur, which renders it more fuſible.

Red Arſenic, which contains ſtill more Sulphur, melts alſo more eaſily. It then becomes of a tranſparent red, like a ruby: and hence, when it is in this form, it is called *Ruby of Arſenic*.

When a combination of Sulphur and Arſenic is wanted, it is better to mingle and diſtill together ſuch minerals as contain Sulphur and Arſenic, the white and the yellow pyrites, for inſtance, than to mingle pure Arſenic with pure Sulphur: for the great volatility of theſe two ſubſtances is a hinderance to their uniting; whereas, when combined with other matters, they are capable of ſuſtaining a much greater degree of heat, which favours and promotes their union.

Thoſe who work by the great do not extract Arſenic out of Cobalt by diſtillation: they throw the ore mixed promiſcuouſly with wood and charcoal into a great furnace, from whence a flue carries the vapours into a long winding paſſage, acroſs which beams of wood are fixed at proper diſtances from each other. The Arſenical vapours being conducted into this paſſage, gather both to the ſides thereof and to the joiſts that ly acroſs it. The fuliginous parts of the combuſtible matters being lighter aſcend higher, and go out through a chimney at the farther end of this paſſage.

The Arſenic ſublimed by this method is not white, but of a grey colour; owing to the inflammable matter of the wood and charcoal, with which the ore is torrefied.

When all the Arſenic the Cobalt will yield is thus ſeparated, the earthy fixed matter left behind is mixed with divers fuſible matters and vitrified, and produces a glaſs of a beautiful blue colour. It is called *Smalt*. This glaſs is to be prepared in the following manner.

Take four parts of fine fuſible ſand, an equal quantity of any Fixed Alkali perfectly depurated, and one part of Cobalt from which the Arſenic hath been ſublimed by torrefaction. Pulverize theſe different ſubſtances very finely, and mix them thoroughly together; put the mixture into a good crucible, cover it, and ſet it in a melting furnace. Make a ſtrong fire, and keep it up conſtantly in the ſame degree for ſome hours. Then dip an iron wire into the crucible; to the end of which a glaſſy matter will ſtick, in the form of threads, if the fuſion and vitrification be perfect. In this caſe take the crucible out of the fire; cool it by throwing water on it, and then break it. You will find in it a glaſs, which will be of an exceeding deep blue, and almoſt black, if the operation hath ſucceeded.

This glaſs, when reduced to a fine powder, acquires a much brighter and more lively blue colour.

If you find after the operation that the glaſs hath too little colour, the fuſion muſt be repeated a ſecond time, with twice or thrice the quantity of Cobalt. If, on the contrary, the glaſs be too dark, leſs Cobalt muſt be uſed.

Inſtead of the mixture here preſcribed you may employ a ready made glaſs, providing it be white and fuſible. But as glaſs is always hard to melt, and as the mixing Cobalt with it renders it ſtill more refractory, therefore though an Alkaline Salt be one of the ingredients in its compoſition, it is proper to promote the fuſion, by mixing therewith calcined wine-lees, in the quantity of one third part of the weight of the Cobalt.

In order to make the aſſay of a particular Cobalt, with a view to know what quantity of blue glaſs it will yield, it is not neceſſary to perform the operation in the manner here ſet down; a great deal of time and trouble may be ſaved by melting one part of Cobalt with two or three parts of Borax. This Salt is very fuſible, and turns, when melted, into a ſubſtance which, for a time, poſſeſſes all the properties of glaſs. In this trial the glaſs of Borax will be nearly of the ſame colour as the true glaſs, or Smalt, made with the ſame Cobalt.

The ores of Biſmuth, as well as Cobalt, yield a matter that colours glaſs blue; nay, the Smalt made with thoſe ores is more beautiful than that procured from the ore of pure Arſenic. Some Cobalts yield both Arſenic and Biſmuth. When ſuch Cobalts are uſed, it is common to find at the bottom of the crucible a little button of metallic matter, which is called *Regulus of Cobalt*. This Regulus is a ſort of Biſmuth, generally adulterated with a mixture of ferruginous and arſenical parts.

The heavieſt and moſt fixed Flowers of Arſenic, procured from Cobalt, have likewiſe the property of giving a blue colour to glaſs. But this colour is faint: it is owing to a portion of the colouring matter carried up along with the Arſenic. Theſe Flowers may be made an ingredient in the compoſition of blue glaſs, not only becauſe of the colouring principle they contain, but alſo becauſe they greatly promote fuſion; Arſenic being one of the moſt efficacious fluxes known.

In ſhort all thoſe blue glaſſes, or Smalts, contain a certain quantity of Arſenic; for a portion of this ſemi-metal always remains united with the fixed matter of the Cobalt, though roaſted for a long time, and in a very hot fire. The portion of Arſenic that is thus fixed vitrifies with the colouring matter, and enters into the compoſition of the Smalt.

The blue glaſs made with the fixed part of Cobalt hath ſeveral names, according to the condition in which it is. When it hath undergone the firſt imperfect degree of fuſion only it is called *Zaffre.* It takes the name of *Smalt* when perfectly vitrified: and this again being pulverized is called *Powder-Blue*; or, if finely levigated, *Blue Enamel*; becauſe it is uſed in enamelling, as well as in painting earthen ware and porcelain.

PROCESS II.

To ſeparate Arſenic from Sulphur.

POWDER the yellow or red Arſenic which you intend to ſeparate from its Sulphur. Moiſten this powder with a Fixed Alkali reſolved into a liquor. Dry the mixture gently; put it into a very tall glaſs cucurbit, and fit on a blind-head. Set this cucurbite in a ſand bath; warm the veſſels gently, and increaſe the fire by degrees, till you perceive that no more Arſenic ſublimes. The Arſenic, which before was yellow or red, riſes into the head partly in white flowers, and partly in a compact, white, ſemi-tranſparent matter, which looks as if it were vitrified. The Sulphur combined with the Fixed Alkali remains at the bottom of the cucurbite.

OBSERVATIONS.

A FIXED Alkali hath more affinity than any metallic ſubſtance with Sulphur: ſo that it is not ſurpriſing Sulphur ſhould be ſeparated from Arſenic by its interpoſition. Yet there is an inconvenience attends the uſe of it: for it hath a great affinity with the Arſenic alſo, and ſo always retains ſome part thereof, which continues fixed with it. For this reaſon care ſhould be taken not to mix, with ſulphurated Arſenic, a greater quantity of Alkali than is neceſſary to abſorb the Sulphur it contains. Nothing, however, but experience and repeated trials can teach us the exact quantity of Alkali that ought to be employed; becauſe the quantity of Sulphur that may be contained in yellow or red Arſenic is indefinite.

The veſſel ought to be tall, that the upper part of the head, where the Arſenical particles condenſe, may be the leſs expoſed to heat. Towards the end of the operation the fire muſt be ſtrongly excited, ſo as to make the ſand red-hot; becauſe the laſt portions of Arſenic that riſe are ſtrongly retained by the Fixed Alkali.

Arſenic that is grey or blackiſh may be depurated and whitened by the ſame means; becauſe a Fixed Alkali abſorbs the phlogiſton likewiſe with great avidity. Mercury, as well as a Fixed Alkali, is an excellent additament for ſeparating Arſenic from Sulphur. If you will uſe it for that purpoſe, reduce the ſulphurated Arſenic to a very fine powder, by rubbing it a long time in a glaſs mortar; when it is well pulverized, let a few drops of Mercury fall upon it, by ſqueezing it through chamoy, and continue the trituration. The yellow or red colour of the Arſenic will inſenſibly change, and gradually grow darker as the Mercury incorporates with it. When the Mercury is perfectly killed, add a little more of it than you did the firſt time, and in the ſame manner: continue to triturate till it diſappear; and thus go on adding more and more till the Mercury you add remain quick, and you can kill no more of it. Neither the red nor the yellow colour will then appear in the mixture; which will be grey, if it contain but a little Sulphur, and black, if a great deal.

Put this mixture into a very tall glaſs cucurbite; fit on a blind-head; ſet it in a ſand-bath, and bury it in the ſand as far as the contained mixture reaches. Heat the veſſels, and during the whole operation keep up a degree of fire a little weaker than that required for ſubliming Cinabar. White Arſenical Flowers will adhere to the upper part of the head, amongſt which will be ſome beautiful cryſtals of Arſenic; and underneath them you will find ſome Cinabar ſublimed, but not entirely free from Arſenic. If you deſire to have your Cinabar and your Arſenic purer, and more unmixed with each other, ſeparate the upper ſublimate, which is Arſenical, from the lower, which conſiſts chiefly of Cinabar. Powder each of them coarſely, and ſublime them ſeparately each in a different cucurbite.

On this occaſion the Mercury ſeparates the Sulphur from the Arſenic, becauſe it hath a greater affinity than Arſenic with that mineral. It is not the only metallic ſubſtance of this character: for, as hath been ſhewn, there are ſeveral others that have a greater affinity than Mercury with Sulphur, being able to decompoſe Cinabar by their interpoſition. Yet thoſe metallic ſubſtances muſt not be ſubſtituted for Mercury in the preſent operation: becauſe there is none of them but hath at the ſame time a very great affinity with Arſenic, or even as ſtrong an one as they have with Sulphur; whereas Mercury will by no means unite with Arſenic.

This method of ſeparating Arſenic from Sulphur hath two advantages over that in which a Fixed Alkali is the medium. The firſt is, that by this means all the Arſenic contained in the mixture is extracted out of it; and the ſecond, that, as Mercury doth not abſorb Arſenic, we are not put to the trouble of groping out, as it were, by trials the quantity neceſſary to be added; and that though more be added than is neceſſary to abſorb all the Sulphur, it will be of no prejudice to the operation. But then it is attended with the inconvenience of being much more tedious and more laborious than the other. For, in the firſt place, it requires previouſly a very tireſome trituration, in order to procure an union between the Sulphur and the Mercury, and ſo to form an Æthiops; without which the Mercury and the ſulphurated Arſenic will ſublime ſeparately, ſo that no decompoſition will be effected. Secondly, though the Mercury be ſufficiently united with the Sulphur of the Arſenic by the long trituration that precedes the ſublimation, this doth not prevent, as we took notice above, the ſublimed Arſenic and Cinabar from being in ſome meaſure blended together; ſeeing each requires a ſecond ſeparate ſublimation to render it very pure.

Theſe inconveniences cauſe a Fixed Alkali to be uſed preferably to Mercury; the loſs of a ſmall quantity of the Arſenic, which remains united with the Alkali, being little regarded, as that metallic ſubſtance is neither ſcarce nor precious.

When

When Arſenic is united with a great quantity of Sulphur, it may be freed from a part thereof without the intervention of any third body : it is ſufficient for the purpoſe to ſublime it with a very gentle fire, encreaſed by inſenſible degrees. The moſt ſulphureous part aſcends firſt ; what riſes afterwards is more Arſenical, and leſs ſulphureous ; and the laſt flowers of all are pure Arſenic, or at leaſt nearly ſo.

PROCESS III.

To give Arſenic the Metalline Form. Regulus of Arſenic.

TAKE two parts of white Arſenic in fine powder, one part of the black flux, half a part of Borax, and as much clean iron filings. Rub the whole together, in order to mix them thoroughly. Put this mixture into a good crucible, and over it put Sea-ſalt three fingers thick. Cover the crucible ; ſet it in a melting furnace ; and begin with a gentle fire to heat the crucible equally.

When arſenical vapours begin to aſcend from the crucible, raiſe the fire immediately ſo as to melt the mixture. Examine whether or no the matter be thoroughly melted, by introducing an iron wire into the crucible ; and if the fuſion be perfect, take the crucible out of the furnace. Let it cool ; break it ; and you will find in it a Regulus of a white and livid metallic colour, very brittle, ſcarcely hard, but rather friable.

OBSERVATIONS.

WHITE Arſenic is, as hath been ſaid, a metallic calx ; and conſequently wants no more, in order to its acquiring the metalline properties, than to be combined with the phlogiſton: this is effected by the operation before us.

The Iron added doth not ſerve here, as in making the Regulus of Antimony, to precipitate the Regulus of Arſenic, by ſeparating it from ſome other ſubſtance with which it was united: on this occaſion it does nothing but join the Regulus of Arſenic, to which it gives ſolidity and conſiſtence. This is the only reaſon of its being made an ingredient in the mixture; as the Regulus of Arſenic, without it, would have ſuch a tender conſiſtence that it could ſcarce be handled without falling aſunder into little bits. The Iron procures a further advantage in this proceſs; which is, that it prevents a great quantity of Arſenic from being loſt in vapours: for the Arſenic, with which it combines, is reſtrained and, in ſome meaſure, fixed by it.

Copper may be ſubſtituted for Iron, and procures the ſame advantages.

It is very neceſſary to remove the crucible from the fire as ſoon as the matter is melted, and indeed to cool it as expeditiouſly as poſſible, to prevent the Arſenic from flying off in vapours: for, when once the Regulus is formed, the proportion of Arſenic, with reſpect to that of the metal mixed with it, is continually leſſening while it ſtays in the fire; ſo that after ſome time there will be left in the crucible, not a Regulus of Arſenic, but only Iron or Copper, alloyed with a little Arſenic. On this occaſion the Copper turns white, and aſſumes the colour of Silver; but it ſoon tarniſhes in the air.

It is eaſy to perceive, by what hath been ſaid, that the Regulus of Arſenic made according to this proceſs is never pure, but contains always a conſiderable quantity of Iron or Copper, whatever precautions be uſed: but it is difficult to avoid this inconvenience, for the reaſons above aſſigned; and if we attempt to fuſe Arſenic alone with reducing fluxes, the greateſt part thereof is diſſipated in vapours, long before the very flux begins to melt: and that part of it, which is found metallized, is not collected in one maſs at the bottom of the crucible, as in other metallic reductions; but in ſmall particles, diſperſed and mixed among the ſcoriæ. There are nevertheleſs ſeveral expedients for obtaining a Regulus of Arſenic abſolutely pure, and unalloyed with any metallic ſubſtance.

Firſt: into a little low cucurbit, covered with a blind-head, put Regulus of Arſenic made with Iron or Copper; ſet this cucurbit in a ſand-bath; heat it till the ſand begins to grow red; and you will ſee part of the Regulus ſublime into the head, ſtill retaining its metallic ſplendour. The portion of Regulus thus ſublimed is pure Arſenic, or at leaſt contains but a very ſmall portion of the adventitious metal, which may have been carried up with it. What is left in the bottom of the cucurbit is the metal that was added, ſtill containing a little Arſenic, which continues obſtinately fixed with it, and which the violence of fire is unable to force away from it in cloſe veſſels.

Secondly: mix your Arſenic in equal parts with the black flux; put the mixture into ſuch a cucurbit as that laſt mentioned; and apply to it the ſtrongeſt degree of heat that can be procured by a ſand-bath: arſenical flowers, of a blackiſh grey colour, will firſt ſublime into the head, and after them a Regulus of Arſenic of a white metalline colour, which is pretty gloſſy, but tarniſhes very ſoon in the air. This Regulus hath no ſolidity: it is exceeding friable; but it is pure.

Thirdly: I have alſo made a Regulus of pure Arſenic by another method, which produces a much greater quantity thereof, with a much ſmaller degree of heat. For this purpoſe I powder the Arſenic, and mix it with any Fat Oil; ſo that the mixture may be like a liquid paſte: this paſte I put into a little phial of thin glaſs, like one of thoſe uſed by apothecaries; I ſet this phial in a ſand-bath, and gradually heat it till the bottom of the pot containing the ſand begin to be red. Part of the Oil firſt riſes out of the phial in vapours, which muſt be ſuffered to paſs off. After this the upper part of the phial is gradually lined on the inſide with a glittering metallic cruſt, which makes it look like a quick-ſilvered glaſs. This cruſt is the Regulus of Arſenic. When it begins to ſublime, the mouth of the phial muſt be ſlightly ſtopped with a bit of paper, and the heat increaſed a little till you ſee that nothing more riſes.

If you break the bottle after the operation, you will find its upper part cruſted over with a coat of Regulus, thicker or thinner in proportion to the quantity of Arſenic employed. The Regulus is in a maſs, of a beautiful brilliant colour, which to me ſeems to ſtand the air better than that of any Regulus made by other methods; probably becauſe of the great quantity of fat matter with which it is united, and by which it is defended.

This Regulus of Arſenic is abſolutely pure, and a much greater quantity thereof is obtained by this method than by treating it with the black flux; becauſe the Arſenic is much ſooner and more eaſily combined with the inflammable matter: and hence it comes to paſs that part of the Arſenic doth not riſe at firſt in grey flowers, as in operating with the black flux. Moreover, by our proceſs, all the Arſenic is ſublimed in Regulus: whereas, when the black flux is employed, a pretty conſiderable part of the Arſenic unites with the alkaline part of the flux, and remains fixed therewith. In our operation there is nothing left at the bottom of the phial, except an oily, light, but very fixed coal.

Regulus of Arſenic, in whatever manner made, may be eaſily reduced into white, cryſtalline Arſenic, by the means of a Fixed Alkali, or of Mercury, applied in the ſame manner as for ſeparating Arſenic from Sulphur.

PROCESS IV.

To diſtill the Nitrous Acid by the interpoſition of Arſenic. Blue Aqua Fortis. *A new Neutral Salt of Arſenic.*

PULVERIZE finely any quantity you pleaſe of refined Salt-petre. Mix it accurately with an equal weight of white cryſtalline Arſenic well pulverized, or elſe with very white and very fine flowers of Arſenic. Put this mixture into a glaſs retort, leaving one half of it empty. Set your retort in a reverberating furnace; apply a receiver having a ſmall hole drilled in it, and containing a little filtered rain-water; lute the receiver to the retort with ſtiff lute. Begin with putting two or three ſmall live coals in the aſh-hole of the furnace, and replace them with others when they are ready to go out. Go on thus warming your veſſels by inſenſible degrees, and put no coals in the fire-place till the retort begin to be very warm. You will ſoon ſee the receiver filled with vapours of a dark-red, inclining to a ruſſet colour. With a bit of lute ſtop the little hole of the receiver. The vapours will be condenſed in the water of this veſſel, and give it a very fine blue colour, that will grow deeper and deeper as the diſtillation advances. If your Salt-petre was not very dry, ſome drops of Acid will alſo come over, and falling from the noſe of the retort mix with the water in the receiver. Continue your diſtillation, increaſing the fire little by little as it advances, but exceeding ſlowly, till you ſee that when the retort is red-hot nothing more comes off; and then let your veſſels cool.

When the veſſels are cold, unlute the receiver, and as expeditiouſly as you can pour the blue *Aqua Fortis* it contains into a cryſtal bottle; which you muſt ſeal hermetically, becauſe this colour diſappears in a ſhort time when the liquor takes air. You will find in the retort a white ſaline maſs moulded in its bottom, and ſome flowers of Arſenic ſublimed to its upper cavity, and into its neck.

Pulverize the ſaline maſs, and diſſolve it in warm water. Filter the ſolution, in order to ſeparate ſome arſenical parts that will be left on the filter. Let the filtered liquor evaporate of itſelf in the open air; when it is ſufficiently evaporated, cryſtals will ſhoot in it repreſenting quadrangular priſms terminated at each extremity by pyramids that are alſo quadrangular. Theſe cryſtals will be in confuſed heaps at the bottom of the veſſel: over them will be other cryſtals in the form of needles; a ſaline vegetation creeping along the ſides of the veſſel; and the ſurface of the liquor will be obſcured by a thin duſty pellicle.

OBSERVATIONS.

ARSENIC, as we took notice in our Elements of the Theory, beſides the properties it hath in common with metallic ſubſtances, poſſeſſes others alſo in common with ſaline ſubſtances. One of the moſt remarkable among the latter is that of decompoſing Nitre; of expelling the Acid of that Salt from its Alkaline baſis, aſſuming its place, and forming with that Alkali a Neutral Salt, which is very ſoluble in water, and ſhoots into regular cryſtals.

To enquire into what paſſes in the decompoſition of Nitre by Arſenic, and into the new Salt reſulting from thence, was the deſign of the firſt Memoir given in by me to the Academy of Sciences on this ſubject, and from that the preſent proceſs is copied. Though the whole quantity of Arſenic preſcribed in the proceſs doth not enter into the compoſition of the new Neutral Salt, ſeeing ſome of it ſublimes in flowers, that quantity muſt not therefore be thought too great; for we ſee, on the other hand, that part of the Nitre is not decompoſed. The needle-like Salt is no other than Nitre that hath not ſuffered any decompoſition, and actually deflagrates on live coals like common Nitre.

The precaution of putting ſome water in the receiver is abſolutely neceſſary to condenſe the nitrous vapours that riſe in the diſtillation: for they are ſo elaſtic, ſo volatile, ſo dephlegmated, that a very ſmall part of them will otherwiſe be condenſed into a liquor, while the reſt will remain in the form of vapours, to which vent muſt be given through the ſmall hole in the receiver, as without that they will burſt the veſſels with impetuoſity: and conſequently ſcarce any Acid will be obtained; eſpecially if the Nitre employed be very dry, as it muſt be to be reducible into a fine powder.

The blue colour communicated by the Nitrous Acid to the water is very remarkable. The cauſe that produces this colour is not yet known.

Though the Acid is, on this occaſion, mortified by a great quantity of water, yet when it riſes out of the retort it is ſo concentrated as to form, even with that water, if too much be not put in, a moſt active and even ſmoking *Aqua Fortis*.

It is neceſſary in this operation, and more ſo than in any other, to warm the veſſels gradually, and to proceed exceeding ſlowly; otherwiſe the Artiſt runs the riſque of ſeeing his veſſels burſt to pieces with violence, and of great danger to his perſon: for Arſenic acts on Nitre with incredible vivacity; in ſo much that, if a mixture of Nitre and Arſenic be heated to a certain degree, the Nitre is decompoſed almoſt as ra-

rapidly, and with as great an exploſion, as when it is made to fulminate with an inflammable matter. In ſhort, the appearances are ſuch that one would be almoſt induced to think the Nitre really takes fire on this occaſion; though it be only decompoſed, juſt as it is by the Vitriolic Acid.

The ſolution of the *caput mortuum* of this diſtillation contains at the ſame time ſeveral ſorts of Salts: to wit, 1. the Neutral Salt of Arſenic formed by the union of the Arſenic with the baſis of the Nitre; this ſhoots into the priſmatic cryſtals above mentioned: 2. ſome Nitre that hath not been decompoſed; this forms the needles and part of the vegetations: 3. a ſmall portion of Arſenic that is known to be ſoluble in water; this forms the thin dark pellicle that covers the ſurface of the liquor when it begins to evaporate.

For the properties of this new Neutral Salt of Arſenic you may conſult what we have ſaid thereupon in our Elements of the Theory, and in the Memoirs of the Academy of Sciences.

PROCESS V.

To alkalizate Nitre by Arſenic.

MELT in a crucible the Nitre you intend to alkalizate. When it is melted, and moderately red, project upon it two or three pinches of pulverized Arſenic. A conſiderable effervеſcence and ebullition will immediately be produced in the crucible, attended with a noiſe like that which Nitre makes when it detonates with an inflammable matter. At the ſame time a thick ſmoke will riſe, which at firſt will ſmell like garlick, the odour peculiar to Arſenic; it will alſo ſmell afterwards like Spirit of Nitre. When the effervеſcence in the crucible is over, throw again upon the Nitre as much pulverized Arſenic as you did the firſt time; and all the ſame phenomena will be repeated. Continue thus throwing in Arſenic in ſmall parcels, till it produce no more effervefcence; taking care to ſtir the matter at every projection with an iron wire, the better to mix the whole together. Then encreaſe your fire, and melt what remains. Keep it thus in fuſion for a quarter of an hour, and then take the crucible out of the fire. It will contain a Nitre alkalizated by Arſenic.

OBSERVATIONS.

THIS operation, as well as the preceding one, is a decompoſition of Nitre by Arſenic; yet the reſult is very different: for, inſtead of a Salt capable of cryſtallizing, and diſcovering no tokens either of Acid or Alkali, we obtain, on this occaſion, only a Salt that runs into a liquor by the moiſture of the air, doth not cryſtallize, and hath all the properties of an Alkali.

Theſe differences ariſe only from the different manner in which the decompoſition of the Nitre, and the union of the Arſenic with the baſis of that Salt, is brought about. When the Nitrous Acid is diſtilled by the interpoſition of Arſenic, with a view to obtain the Arſenical Salt, the operation muſt be performed in cloſe veſſels; no greater degree of heat muſt be applied to the mixture than is neceſſary for enabling the Arſenic to act; and that heat muſt be adminiſtered very ſlowly and by inſenſible degrees. But, when the buſineſs is to alkalizate Nitre by the means of Arſenic, the operation is performed in a crucible, in a naked fire, with a ſtrong degree of heat, and that ſuddenly applied. The violence of the heat, the ſuddenneſs with which it is applied, the vivacity wherewith the Arſenic unites with the baſis of the Nitre; and, ſtill more than all theſe, the free acceſs of the air, occaſion the greateſt part of the Arſenic, which at firſt combines with the baſis of the Nitre after having expelled its Acid, to be preſently carried off and diſſipated in vapours; and conſequently the baſis of the Nitre, not being ſufficiently ſaturated, diſcovers its Alkaline properties.

I ſay the concurrence of the air contributes ſtill more than all the reſt to ſeparate the Arſenic from the Alkaline baſis of the Nitre; experience having taught me that the Neutral Salt of Arſenic is not to be alkalizated by the moſt violent force of heat, as long as it continues in cloſe veſſels, and the external air hath no communication with it; but that ſome of the Arſenic contained in that Salt is diſſipated by expoſing it to a ſtrong heat in open veſſels.

The tumult and efferveſcence that ariſe, when Arſenic is projected on Nitre fuſed in a crucible, are ſo conſiderable, and ſo nearly reſemble the detonation of Nitre with an inflammable matter, that we ſhould be tempted to think, if we truſted appearances only, that Arſenic furniſhes a combuſtible matter, and that the Alkalization of the Nitre is effected, on this occaſion, in the ſame manner as when it is fixed by charcoal: but, by examining attentively what paſſes, we eaſily diſcover that there is no inflammation at all, and that the Nitre is alkalizated in the manner and by the means above pointed out.

The firſt vapours that riſe, when Arſenic is projected on Nitre, are purely arſenical; and, if any cold body be put in their way, they adhere to it in the form of flowers. Theſe vapours are actual particles of Arſenic, carried up by the heat before they could come to act on the Nitre; but they are ſoon after mixed with nitrous vapours, conſiſting of the Acid of the Nitre, which the Arſenic expels from its baſis as faſt as it comes to act on that Salt.

The nearer you come to the end of the operation, the more does the matter in the crucible loſe of its fluidity, though an equal fire be conſtantly kept up in the furnace. At laſt it becomes quite like a paſte, and the fire muſt be made much ſtronger to put it again in fuſion. The reaſon of this is, that Nitre when alkalizated is much leſs fuſible than when it is not ſo. The caſe is the ſame when this Salt is alkalizated by deflagration.

Though the Nitre when alkalizated makes no more effervescence with Arſenic, and though, when kept in fuſion, it emits no more arſenical vapours, it doth not thence follow that it is a pure Alkali, and that it contains no Arſenic: it ſtill contains a large quantity thereof, but ſo ſtrongly united that the force of fire is not able to ſeparate them; which hath led ſome authors to give this Salt the title of *Fixed Arſenic*.

The exiſtence of Arſenic in this ſaline compound is eaſily diſcovered, by fuſing it with metallic ſubſtances, on which it produces the ſame effects as Arſenic.

With ſolutions of metals in the Acids, it alſo preſents almoſt the ſame phenomena as the Neutral Salt of Arſenic. Particularly it precipitates Silver diſſolved by the Nitrous Acid in a red powder, as that Salt does; and the differences obſerved between the precipitations made by the new Neutral Salt of Arſenic, and thoſe made by Nitre alkalizated with Arſenic, can be attributed only to the Alkaline quality of the latter. See the Memoirs of the Academy for 1746.

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PART II.

OF VEGETABLES

SECTION I.

Operations on unfermented Vegetables.

CHAP. I.

OF THE SUBSTANCES OBTAINED FROM VEGETABLES BY EXPRESSION ONLY.

PROCESS I.

To expreſs and depurate the juice of a Plant, containing its Eſſential Salt. The Cryſtallization of that Salt.

BEFORE ſun-riſe, gather a good quantity of the plant from which you deſign to expreſs the juice, in order to obtain its Salt. Waſh it well in running water, to clear it of earth, inſects, and other adventitious matters. Bruiſe it in a marble mortar; put it into a bag of new, ſtrong, thick linnen cloth; ty the bag tight, and commit it to a preſs. By preſſing it ſtrongly you will ſqueeze out a great quantity of green, thick juice, which will have the ſame taſte as the plant. Dilute this juice with ſix times as much pure rain-water, and filter it repeatedly through a woollen bag, till it paſs clear and limpid. Evaporate the filtered juice with a gentle heat, till it be almoſt as thick as before it was mixed with water. Put this inſpiſſated juice into a jar, or other veſſel of earth or glaſs; on its ſurface pour olive oil to the depth of a line, and ſet it in a cellar. Seven or eight months after this pour off gently the liquor contained in the veſſel, the inſide of which you will find covered with a cryſtallized Salt. Separate the cryſtals gently; waſh them quickly with a little fair cold water and dry them: this is the Eſſential Salt of the plant.

OBSERVATIONS.

EVERY plant is not equally diſpoſed to yield its Eſſential Salt by the method here propoſed. Succulent vegetables only, whoſe juices are aqueous and not too viſcous, are fit for this purpoſe. Such for example as ſorrel, brook-lime, ſuccory, fumitory, water-creſſes, plantain, &c. An Eſſential Salt cannot be procured from thoſe that yield thick viſcid, mucilaginous juices, ſuch as the ſeeds of flea-wort; unleſs their juices be previouſly attenuated by fermentation, and that viſcoſity deſtroyed which obſtructs the Cryſtallization of this Salt.

Nor can the Eſſential Salt be obtained in any quantity from vegetable matters abounding in oil. Moſt kernels and ſeeds are of this ſort: they all contain a great quantity of fat oil, which ſo entangles and clogs this Salt, that the particles thereof cannot ſhoot away from the tenacious juices into cryſtals.

The ſame is to be ſaid of dry aromatic plants; becauſe they contain much eſſential oil, or reſinous matters that produce the ſame effect. It is true the Eſſential Salt itſelf contains a certain portion of oil; for it is no other than the Acid of the plant incorporated and cryſtallized with part of its oil and of its earth: but then the oil muſt not be in too great a quantity; becauſe it ſheaths the Acid, renders it clammy, as it were, and hinders it from extricating itſelf ſo as to be able to exert its qualities, and appear in the form of Salt.

The plants from which you intend to extract this Salt ſhould be gathered in the morning before ſun-riſe; becauſe they are then moſt ſucculent, not being yet dried up or withered by the heat of the Sun.

The juice of plants obtained by expreſſion is very thick; becauſe it contains many particles of the bruiſed plant that are unavoidably ſqueezed out along with it. In order to clear it of theſe ſuperfluous parts it is proper to filter it: but as that would be difficult, on account of the thickneſs of the juice, it muſt be thinned, by diluting it with a quantity of water, ſufficient to give it the requiſite degree of fluidity.

Inſtead of thus diluting the expreſſed juice, the plant may be ground with water before it is put into the preſs: it will by this means furniſh a more fluid juice, that will eaſily paſs through the filter. This method may be employed with ſucceſs on dry plants, or ſuch as are not very ſucculent. For this operation rain-water is to be preferred to any other; becauſe it is the pureſt: for all waters that have run ſome time through the earth, or on its ſurface, are to be ſuſpected of containing ſome ſaline or ſelenitic matter, which would mix with and deprave the Eſſential Salt.

The juice of the plant, when diluted with the quantity of water ſufficient to facilitate its filtration, is too aqueous to let the ſalt it contains unite into Cryſtals: it muſt therefore be evaporated till it hath recovered a ſomewhat thicker conſiſtence. The heat applied for that purpoſe muſt be gentle; leſt the acid and oily parts, that are to form the Salt, be ſpoiled or diſſipated, as they are not very fixed. In ſummer, the heat of the ſun is ſufficient to effect this evaporation: but if you make uſe of this method, the juice to be evaporated muſt be put into ſeveral broad flat pans; that, a larger ſurface being expoſed to the action of the air and ſun, the evaporation may be the ſooner completed: for if the juice ſhould continue too long in the degree of heat requiſite for its evaporation, it might begin to ferment; which would be very detrimental.

The oil poured on the liquor prevents its fermenting, putrefying, or growing mouldy, during the long ſpace of time required for the Cryſtallization of the Eſſential Salt.

Theſe Salts are excellent Medicines, being endued with the ſame virtues as the plants from which they were obtained.

They cannot be procured from plants by diſtillation, though they conſiſt in a great meaſure of volatile principles: nor are they obtainable by any other proceſs that requires much heat; becauſe they are eaſily decompoſed, and the fire changes their natures entirely. The oily Acids extracted from plants by diſtillation do not cryſtallize, and always have an empyreumatic acrimony that makes them very different from the Eſſential Salts, which are very mild and ſaponaceous.

PROCESS II.

To draw the Oils out of Kernels, Seeds, and Fruits, by Expreſſion.

POUND in a marble mortar, or grind in a mill, the kernels, ſeeds, or fruits, out of which you intend to expreſs the Oil. If your matters be meagre, and grind to meal, ſuſpend that meal in the ſteam of boiling water, in order to moiſten it a little, and then dry it.

Ty up your matter thus prepared in a new, ſtrong, thick, canvaſs bag, and put it into a preſs, between two iron plates previouſly heated in boiling water: ſqueeze it ſtrongly, and you will ſee the Oil run in ſtreams into the receiving veſſel.

OBSERVATIONS.

THE Fat Oil of Plants is particularly found in kernels, ſeeds, and ſome fruits; ſome kernels contain ſuch a vaſt quantity thereof, that, on being very ſlightly bruiſed in a mortar, they diſcharge it in great abundance. Sweet and bitter Almonds, Walnuts, and Lint-ſeed, are all of this kind; and require no other management but to be pounded and preſſed to make them yield a great deal of Oil. But there are others more meagre, that being ground produce an almoſt dry flower. In order to facilitate the expreſſion of the Oil out of ſuch, they muſt be expoſed, when ground, to the ſteam of boiling water. For this purpoſe the meal may be put into a fine ſieve, and that ſuſpended over a pan half-full of water kept boiling on the fire. The aſcending vapours will moiſten the flower, render it more unctuous, and facilitate the expreſſion of the Oil.

It is proper to dry it a little before it be put into the preſs, that it may yield as little water as poſſible along with the Oil. Nevertheleſs, ſo much water happens now and then to be left in it, that ſome is expreſſed together with the Oil: but, as oil and water do not incorporate, they are eaſily ſeparated after the operation is finiſhed.

The extraction of the Oil is alſo greatly facilitated by heating the plates, between which the oleaginous matters are ſqueezed: but they muſt not be made too hot, if you mean to have a very mild Oil, deſigned either for aliment or for medicine; ſuch as the Oil of olives, and that of ſweet almonds. For this reaſon the plates muſt be warmed in boiling water only: if you heat them to a greater degree, you run the riſque of giving an acrimony to the Oils you expreſs. But, when theſe Oils are intended for other uſes, the plates may be made hotter, becauſe their heat increaſes the yield of Oil.

It is remarkable that all the Oils obtained by expreſſion, with the precautions above recommended, are conſtantly very mild; even though the matters from which they are extracted be in themſelves very acrid. Muſtard-ſeed, which is ſo acrid that it is even cauſtic, yields, by expreſſion, an Oil as mild as that of ſweet almonds. But then the kernels, ſeeds, and fruits, from which the Oils are extracted, muſt not be old; becauſe theſe Oils, which are perfectly mild when freſh and new, become intolerably acrid when they grow old, and acquire this acrimony even in the fruit itſelf; for it is obſerved that theſe fruits turn rancid as they grow old.

The Fat Oils obtained by expreſſion are uſed in medicine, both internally and externally, as Lenitives and Emollients. Every body knows the great uſe of Oil of ſweet almonds in inflammatory diſtempers of the breaſt and inteſtines. But it muſt be carefully noted that theſe Oils can produce no good effects unleſs they be freſh expreſſed, and from fruits, kernels, or ſeeds that have not been long kept: for they not only loſe their lenient virtue by growing old; but they even acquire an oppoſite quality, and contract ſuch a ſharp acrimony, that far from procuring any ſalutary relief or mitigation to the inflamed parts, they are capable of irritating and inflaming the ſound.

It is therefore of the laſt importance to adminiſter them only when they are quite freſh: they ought never to be above two or three days old. Thoſe that are old are generally more limpid and tranſparent than the freſh, which look a little more cloudy. The beſt way to diſtinguiſh them is to taſte them, and to try whether or no they leave any ſenſation of rancidity on the palate and in the throat.

PRO-

PROCESS III.

To draw the Eſſential Oils of certain Fruits by Expreſſion.

TAKE the rind of a Citron, Lemon, Orange, Bergamot-Pear, or other fruit of that kind; cut it in ſlices, and doubling the ſlices ſqueeze them between your fingers over againſt a poliſhed glaſs ſet upright, with its lower end in a veſſel of earth or porcelain. Every time you ſqueeze the peel in a new ply, there will ſquirt out of it ſeveral fine jets of liquor, which meeting with the ſurface of the glaſs will be condenſed into drops, and trickle down in ſmall ſtreams into the recipient. This liquor is the Eſſential Oil of the fruit.

OBSERVATIONS.

No fruits but thoſe of the kind above-mentioned will yield an Eſſential Oil by expreſſion. The rind of the fruit is the reſervoir of this Oil: it is contained in little veſicles, which may be ſeen by the naked eye ſpread all over the ſurface of the peel, and which burſting when the peel is ſqueezed diſcharge the Oil in the form of very fine ſlender ſpouts. Every body knows that theſe little oily ſtreams inſtantly take fire, when ſpirted through the flame of a candle: the Oil in this caſe is entirely conſumed.

The Eſſential Oil thus obtained by expreſſion hath a very ſweet and moſt agreeable ſcent. It is in every reſpect the ſame as when it made a part of the fruit that yielded it; ſeeing it hath not undergone the action of fire. Yet this method, however good it may be, can hardly be practiſed but in the countries where thoſe fruits are in great plenty; becauſe we cannot by this means obtain any thing near the quantity of Oil they contain.

This inconvenience may be remedied by rubbing the rind, which contains the Eſſential Oil, on the ſurface of a ſugar-loaf. The inequalities of that ſurface produces the effect of a raſp, by tearing all the oily veſicles. The Oil, which iſſues in abundance, is imbibed by the ſugar and moiſtens it. When the ſugar is ſufficiently impregnated therewith, it may be ſcraped off with a knife, and put into a well-ſtopped bottle. The ſugar does not alter the nature of the Oil; which may be kept in this manner for years, and uſed, though combined with the ſugar, for almoſt all the ſame purpoſes as when in a fluid ſtate; that is, to aromatize the ſeveral matters with which you incline to mix it. We owe theſe obſervations to M. Geoffroy.

This experiment, in which the Eſſential Oil of a vegetable is obtained by expreſſion alone, and without the aid of fire, proves that the Oils of this kind exiſt naturally in vegetables; and that the Oils of the ſame kind obtained by diſtillation, as ſhall be ſhewn in its place, are not the product of the fire. Eſſential Oils drawn by expreſſion do not very ſenſibly differ from thoſe procured by diſtillation.

CHAP. II.

OF THE SUBSTANCES OBTAINED FROM VEGETABLES BY TRITURATION.

PROCESS I.

To make the Extracts of a Plant by Trituration.

BRUISE the vegetable ſubſtance of which you intend to make the Extract; or, if it be hard and dry, grind it to a powder: put the matter thus prepared, together with ſeven or eight times as much rain-water, into an earthen veſſel; and into this veſſel fit a churning ſtaff, ſo that it may be continually whirled round with a rotatory motion, by means of a cord, a wheel, and a winch. Ply this machine for ten or twelve hours; and then filter the liquor through two linnen cloths ſpread on a hair-ſieve. Let your filtered liquor ſtand quiet for twelve hours more: then pour it off by inclination from the ſediment you will find at bottom; and filter it a ſecond time through a flannel bag.

Pour freſh water, but in a ſmaller quantity, on the maſs left after trituration with the machine. Triturate it again for four or five hours. Treat the liquor of this ſecond triture juſt as you did that of the firſt, and mix them both together. Diſtribute all the liquor you now have among a ſufficient number of ſhallow earthen plates, and evaporate it by a gentle heat, ſuch as that of the ſun, or of a vapour-bath, to the conſiſtence of an Extract, or even to dryneſs, as you think proper.

OBSERVATIONS.

IN trituration the water takes up, not only the Salts of plants, but alſo a pretty conſiderable quantity of their oily and earthy parts, which thoſe Salts have rendered ſoluble therein, by communicating to them a ſaponaceous and mucilaginous quality. After trituration therefore nothing remains but the groſſeſt particles of oil and earth. Hence it is evident that the water, in which plants have been triturated, contains nearly the ſame principles as the juices of thoſe plants drawn by expreſſion; and that it is alſo impregnated with their Eſſential Salts: ſo that by evaporating it to a due conſiſtence we have a well made Extract of the triturated plant.

The Count de la Garaye, who hath long cultivated with great aſſiduity thoſe parts of Chymiſtry by which Medicine may be improved, hath made a great number of experiments for obtaining from plants, by triture with water, the matters in which their virtues chiefly reſide, and hath alſo publiſhed a work intituled Hydraulic Chymiſtry, in which he gives a particular account of all the proceſſes for making ſuch Extracts of the chief mineral, vegetable, and animal ſubſtances, as are moſt frequently uſed in the Practice of Phyſic. His way of evaporating by a gentle heat the liquor containing the Extract of a triturated ſubſtance is a very good one: for we know that heat, if but a very little too ſtrong, is capable of changing the natures of compound bodies, by diſuniting their principles, and exhaling ſome of them.

If all vegetable matters were fat and ſucculent, as moſt pot-herbs are, triture would not be neceſſary for the making an Extract of them, even without the help of fire. We ſhould have nothing to do, for that purpoſe, but to expreſs their juices, as before, clarify them, and evaporate with a gentle heat to the confiſtence of an Extract. But many vegetable ſubſtances, ſuch as woods, barks, roots, &c. are dry, hard, and compact. Theſe matters will not give out their Extract, without ſuch an application of water as ſhall diſſolve their ſaline, ſaponaceous, and mucilaginous parts. Now this muſt be effected either by triture or by fire. Trituration has the advantage of procuring Extracts in which the principles are perfectly unaltered, and, retain the ſame proportions with reſpect to each other, as in the plant: but then it is attended with the inconveniences of being very tedious, troubleſome, and chargeable. When we come to deliver the methods of making Extracts by decoction and by infuſion, we ſhall ſee what are the advantages and diſadvantages of preparing Extracts by heat.

The matters from which an Extract is to be made by triture muſt be previouſly bruiſed and reduced into ſmall parts, in order to facilitate the action of water upon them. The ſeveral filtrations and decantations here directed are intended to ſeparate the groſſer parts of the plant, that were only ſuſpended in the liquor, but not truly diſſolved, by means of the agitation and motion: for this reaſon alſo, the longer the liquor is left to ſettle, the purer will the Extract be.

Though the plant be triturated the firſt time with a great deal of water, and for a good while too, yet it is not by that means wholly exhauſted: M. de la Garaye therefore directs the remainder to be triturated again with freſh water: but this ſecond operation requires only half the water uſed in the former, and need be continued only half the time; the plant having been already opened by the former triture, and having fewer parts to give out. It is better to add freſh water, and triturate a ſecond time, than to triturate but once and for a greater length of time: for when the water is impregnated with the principles of the plant to a certain degree, it is leſs capable of acting, and of diſſolving more, than when it is pure.

As the water impregnated with the principles of the plant by triture muſt be almoſt wholly evaporated, in order to bring thoſe principles nearer together, and that the whole may lie in the ſmalleſt compaſs poſſible; and moreover, as this evaporation muſt be effected by the gentleſt heat, it is neceſſary to ſpread the liquor ſo, by diſtributing it among a great number of plates, that it ſhall be reduced in a manner entirely to ſurface. By this means the Extract may be evaporated even to dryneſs: and this is M. de la Garaye's practice. As the Extracts thus evaporated to dryneſs cannot be taken up otherwiſe than in little ſcales, the lower ſurfaces whereof, by adhering to the glazing of the plate, are ſmooth and ſhining, they in ſome meaſure reſemble a cryſtallized Salt; which led M. de la Garaye into an errour, and induced him to give the title of Eſſential Salts to the Extracts prepared in this manner. The Eſſential Salt is indeed contained in them: but ſtill they are only Extracts, as Mr. Geoffroy hath ſhewn in a Memoir on this ſubject given in by him to the Academy; ſince, beſides the Eſſential Salt, they contain moreover, as was ſaid before, a great deal of the oil and earth of the matters from which they were extracted. This, in the main, is no objection, but rather an advantage to them; conſidering that ſuch ſaline Extracts are, on that account, ſo much the more like the ſubſtances from which they were obtained; eſpecially with regard to their medicinal properties.

PROCESS II.

To extract from Seeds and Kernels, by Trituration, the matter of Emulſions.

BLANCH the kernels of which you deſire to make an Emulſion; put them into a marble mortar; add a very little water; and pound them with a wooden peſtle. Continue pounding and triturating till the matter become like a white paſte. From time to time pour on it, by little and little, more fair water warmed, ſtill continuing the trituration; by which means the paſte will grow thinner. Go on thus till every particle of your kernels be cruſhed to pap. Then add, ſtill rubbing the mixture, enough of water to make the whole an actual fluid; and you will have a liquor of a dead-white colour, reſembling milk. Strain it through a clean linnen cloth: it will leave on the filter ſome coarſe parts, which muſt be returned to thoſe left in the mortar. Again triturate and rub the remainder of the kernels, with the addition of water as before. This ſecond liquor will not be ſo white nor ſo rich as the former: filter it in the ſame manner, and again grind with water the ſolid parts remaining. In this manner proceed, repeatedly rubbing and adding freſh water, till it appear no longer milky, but come off clear. The white milky waters thus obtained go by the name of an *Emulſion.*

OBSERVATIONS.

ALL the matters, from which a Fat Oil is obtainable by expreſſion, produce Emulſions when triturated with water.

An Emulſion conſiſts chiefly of two ſubſtances. One of theſe is mucilaginous, and ſoluble in water. This ſubſtance by itſelf would not give a milky appearance to the Emulſion, which, with it alone, would be limpid. The other is a Fat Oil, which of itſelf is not ſoluble in water; but being divided by the means of trituration into very ſmall globules, it is diſperſed through the whole liquor, and ſuſpended therein by the aid of the mucilaginous part. It is this oily part that gives the Emulſion its dead-white, milky colour; becauſe it is not actually diſſolved in the water, but only diffuſed through it.

If Oil be mixed with water in a phial, and the mixture ſtrongly ſhaken for ſome time, with a rapid and continued motion, the Oil will be divided into a vaſt number of little globules, which intervening between the parts of the water will deſtroy its tranſparency, and give it a dead-white colour, like that of our Emulſion. But, as the Oil is not ſo minutely divided by this means as by triturating the matters containing it; and again, there being no mucilage in this liquor, as there is in Emulſions, the Oil ſoon ſeparates from the water when it is left at reſt, re-unites into round globules, and theſe joining together riſe to the ſurface of the liquor, which then recovers its tranſparency.

The caſe is not exactly the ſame with Emulſions; but ſomething like it happens to them alſo. If they be left to ſtand quiet in a long bottle, the liquor, which at firſt appeared homogeneous, ſeparates into two manifeſtly different parts. The upper part retains its dead-white colour, but is thicker and more opaque; while the lower part becomes perfectly tranſparent. This is the beginning of an entire ſeparation of the oily from the aqueous parts. The former, being the lighter, aſcend and gain the upper part of the liquor; while the lower, being freed from that which obſtructed its tranſlucence, recovers its proper limpidity: but the oily parts do not re-unite into maſſes large enough to form one homogeneous whole, with the appearance and limpidneſs of Oil; their being minutely divided and entangled in the mucilage impeding their natural tendency.

Emulſions firſt begin to ſpoil, as they grow old, not by turning rancid and acrimonious like the Fat Oils drawn by expreſſion, but by turning ſour; which is owing to the great quantity of mucilage they contain. As there is a Fat Oil in their compoſition, they have the ſame virtues with that ſort of Oil: but they are moreover incraſſating, cooling, and emollient; qualities which render them extremely uſeful in acute and inflammatory diſorders. They grow ſour in a very ſhort time, eſpecially in the heat of ſummer; nay, they ſometimes do ſo in two hours: and therefore they ought to be prepared from time to time as they are to be uſed.

The matter that is left when all the ſubſtance of the Emulſion is extracted, and from which the water comes off clear and limpid, is ſcarce any thing but the earthy part of the ſeed or kernel that was triturated; which, however, ſtill retains a portion of tenacious and groſs Oil, adhering to it ſo firmly as not to be ſeparable by water.

The chyle and milk of animals reſemble an Emulſion in ſeveral reſpects, and particularly in their dead-white colour; which ariſes, in the ſame manner, from the very minute particles of Oil contained in them, and diſtributed through an aqueous, gelatinous fluid, but not diſſolved therein. In general, whenever any Oil of any kind happens to be lodged in this manner between the parts of an aqueous liquor, it always makes the whole of an opaque white: for Oil will not mix with water, ſo as to produce a liquor that ſhall appear homogeneous and tranſparent, unleſs it be intimately diſſolved in the water; which cannot be effected but by means of an union previouſly contracted between it and ſome ſaline matter; as is the caſe of mucilages, certain ſaponaceous matters, and ſome other combinations of which we ſhall have occaſion to treat in the ſequel.

The methods we have hitherto propoſed, for extracting from vegetable ſubſtances all that they will yield without the aſſiſtance of fire, are not capable of analyzing thoſe ſubſtances accurately, as you may have obſerved; ſince by expreſſion and trituration we obtain only the liquid parts, impregnated indeed with almoſt all the principles of plants, which however are ſtill combined with each other, and barely ſeparated from the groſſeſt earthy and oily parts. We muſt therefore neceſſarily have recourſe to a more effectual expedient for carrying our analyſis further. This expedient conſiſts in making them undergo the action of fire, ſucceſſively graduated, from the gentleſt to the moſt violent heat.

But, before we enter on this Analyſis of Vegetables, it is proper to deſcribe the different operations that may be performed on Oils, the only pure principle we have been able to obtain without the help of fire. As we ſhall have occaſion, when we come to treat of the analyſis of plants by fire, to ſay a great deal more concerning Eſſential Oils, we reſerve till then what relates to the operations that may be performed on them; and confine our ſelves here to the operations on Fat Oils.

CHAP. III.

OF OPERATIONS ON FAT OILS.

PROCESS I.

To attenuate Fat Oils, and change their nature, by expoſing them to the action of fire, and diſtilling them.

MIX thoroughly three or four pounds of any Fat Oil whatever with twice its weight of lime ſlaked in the air. Put this mixture into a large earthen retort, leaving a third part of it empty. Set it in a reverberating furnace, and lute on a receiver. Heat the veſſel with a very gentle fire. A little phlegm will riſe firſt, and will ſoon be followed by an Oil that will fall in drops from the noſe of the retort. Continue the diſtillation very ſlowly, till you perceive the Oil that comes over begin to be not quite ſo fluid as before, but rather a little thicker.

Then unlute your receiver, and put another in its place. Continue the diſtillation, encreaſing your fire by degrees. The oil that comes over will grow thicker and thicker, its fluidity will decreaſe, and it will acquire a dark-brown colour, which at laſt will become blackiſh. The Oil will then be very thick. Puſh the operation till nothing more will come off, though the retort be red-hot. During the whole time this diſtillation laſts there riſes a good deal of water in company with the Oil. Keep the ſecond thick Oil by itſelf.

Mix the Oil that came over firſt in this operation with an equal part of freſh lime ſlaked in the air.

Put the mixture into an earthen or glaſs retort of a ſize ſo proportioned to the quantity, that a third part thereof may remain empty. Diſtill as before. The ſame phenomena will appear: a clear Oil will firſt come over, and be ſucceeded by one a little thicker. Then ſhift your receiver, and diſtill off all the reſt of the Oil with an encreaſed fire. The firſt Oil obtained by this ſecond diſtillation will be clearer and thinner than that of the firſt diſtillation; and the ſecond Oil will not be ſo thick nor of ſo deep a colour as before.

Diſtill over again in the ſame manner the thin Oil of this ſecond diſtillation, and go on thus repeatedly diſtilling, till the firſt clear Oil come over with a degree of heat not exceeding that of boiling water. Then, inſtead of mixing your Oil with lime, put it with ſome water into a glaſs retort, or into a body with its head fitted on, and diſtill it, keeping the water juſt in a ſimmer. Your Oil will be more and more attenuated, and, after being thus diſtilled twice or thrice with water, will be ſo limpid, ſo thin, and ſo clear, that you will ſcarce be able to diſtinguiſh it from water it ſelf.

OBSERVATIONS.

FAT Oils, which are naturally mild, unctuous, inodorous, or have at moſt a ſcarce perceptible ſmell, reſembling that of the fruit or kernel from which they were extracted, change their natures totally when expoſed to the action of fire. If they be but heated ſo as to boil, they become acrid, loſe much of their unctuouſneſs, and acquire a very pungent odour. From ſeveral analogies, and by ſeveral experiments, recited in a Memoir on Oils which I read to the Academy, I ſhewed that theſe alterations of Fat Oils are produced by the fire's extricating an Acid in them, which before lay concealed and inactive. What I advanced on this ſubject may be ſeen in the Memoirs of the Academy for 1745, and in my Elements of the Theory of Chymiſtry. I ſhall take occaſion to add ſomething more, in my Obſervations on the following proceſs by which theſe Oils are combined with Acids. In this place I ſhall only examine what paſſes in the repeated diſtillations they are here made to undergo.

Fat Oils do not riſe in diſtillation without a degree of heat greater than that of boiling water; and therefore they muſt be diſtilled in a ſand-bath or a naked fire. We prefer the latter method, for reaſons elſewhere aſſigned, and chiefly becauſe the Operator is more maſter of his fire; it being abſolutely neceſſary, in this operation, that he have it in his power to ſupprefs it in an inſtant, when he finds it too ſtrong: for, in ſuch a caſe, it will impetuouſly raiſe the thin Oil mixed with the thick; nay, the whole will be burnt, as it were, to a coal, if a degree of fire ever ſo little too ſtrong be kept up but for a few moments. When this accident happens, it is always predicted by a great quantity of white vapours aſcending with impetuoſity out of the retort, and by drops of Oil following each other very faſt, that are ſcarce limpid at firſt, and ſoon become of a dark colour. All this may be prevented by diſtilling very ſlowly, and with great patience.

Fat Oils may be diſtilled and attenuated without any additament: but then the operation, which is tedious and troubleſome enough, even when lime is uſed, as appears from our deſcription of the proceſs, would be much more ſo if the Oil were diſtilled alone, without the addition of any thing to divide it, ſpread it, and enlarge its ſurface.

Lime is one of the beſt additaments that can be employed on this occaſion; not only becauſe it procures the advantages juſt mentioned, but alſo by reaſon that, being an abſorbent of fat matters, it unites with the groſſer parts of the Oil, retains them; and ſo allows the thinneſt and lighteſt parts to be readily ſeparated from the reſt. By this means it greatly expedites the operation; and, the more of it is added, with reſpect to the oil, the ſooner is a conſiderable quantity of thin limpid Oil obtained: and this is the reaſon of our directing a double quantity of lime to be mixed with the Oil in the firſt diſtillation.

Lime ſlaked in the air is employed preferably to quick-lime; becauſe it is naturally divided into a very fine powder, and capable of mixing perfectly with all ſorts of matters.

The water that firſt appears in the diſtillation comes from the lime: it is part of the humidity the lime had imbibed from the air. This water continues to riſe with the Oil during the whole diſtillation, according as the degree of heat is encreaſed: and, if the diſtillation be finiſhed by keeping the retort red-hot for ſome time after all is come over, the lime in it will have a greyiſh caſt, and, when water is poured on it, grow almoſt as hot as quick-lime.

If you reſolve to carry on theſe diſtillations of a Fat Oil, till it become as light as an Eſſential Oil, it is neceſſary to begin with a pretty large quantity thereof, as three or four pounds: for the quantity of the Oil is conſiderably leſſened by every diſtillation; not only becauſe the thickeſt and groſſeſt part is ſeparated from it every time; but alſo becauſe a portion of the Oil remains ſo ſtrongly united with the lime, that the force of fire is not able to ſeparate them. Moreover, there is reaſon to believe that ſome of it is decompoſed every time it is diſtilled.

If Oil be diſtilled by itſelf, the thickeſt and heavieſt part remains charred, as it were, in the retort, the inſide of which is lined with a cruſt of coal, that is to the laſt degree fixed: this therefore always occaſions a diminution of the Oil.

A Fat Oil muſt be diſtilled eight or nine times, even with lime, before it become as light as an Eſſential Oil, and capable of riſing wholly with the heat of boiling water: by that time therefore it muſt be conſiderably diminiſhed; and if, at leaſt, the quantity preſcribed be not taken at firſt, there will ſcarce remain a few ounces capable of being diſtilled with water.

The portion of thick heavy Oil, obtained in the ſeveral diſtillations, may, if you will, be rectified again. For this purpoſe you muſt mix it with freſh lime, and diſtill it as you did the clear Oil. A portion of this alſo will be attenuated, and come over firſt. Thus all the Fat Oil may be ſubtilized by the action of fire; an abſolutely charred black part excepted, that remains fixed, and appears ſuſceptible of no change, but by burning it in the open air, and thereby reducing it to aſhes, from which a little Fixed Alkali may be obtained. This fixed part of the Oil is that wherein the acid and earthy parts are combined therewith in a greater proportion than they ought to be in pure Oil.

The portion of Oil that hath become light and thin is nothing but the pureſt oily part, ſeparated from the groſs Acids, and from a certain quantity of earth, which made it thick and heavy. This Oil reſembles the Eſſential Oils in lightneſs, fluidity, and a penetrating agreeable odour: it diſſolves in Spirit of Wine. We ſhall have occaſion in the ſequel to enlarge further on the qualities of the ſeveral ſorts of Oils, and their ſolubility in Spirit of Wine, when we come to treat of Ardent Spirits and of Æther.

PROCESS II.

To combine Fat Oils with Acids. The decompoſition of this combination.

PUT any Fat Oil whatever into a glaſs baſon, and ſet it in a ſand-bath very moderately heated. Pour on this Oil an equal quantity of concentrated Oil of Vitriol, which will immediately diſſolve it with violence; a conſiderable ebullition and effervefcence will ariſe, attended with great heat, and a prodigious quantity of black, thick vapours, in which may be eaſily perceived the ſmell of burnt Oil, together with that of a Sulphureous Acid. The mixture will become of a deep-red, black, and thick. Stir it with a ſmall ſtick, till you obſerve that all is quiet.

OBSERVATIONS.

THE Vitriolic and Nitrous Acids unite with Fat Oils, and diſſolve them with violence; but theſe Acids muſt be ſufficiently ſtrong and concentrated, otherwiſe they will not act upon the Oils. The Vitriolic Acid in particular diſſolves them pretty thoroughly. If hot water be poured on the mixture deſcribed in our proceſs, this water will become cloudy and milky, by diſſolving ſome of it: ſo that Oils may be rendered ſoluble in water by the means of Acids. Spirit of Wine, which doth not attack Fat Oils in their natural ſtate, unites perfectly with them, and makes a clear limpid ſolution of them, when they are thus combined with Acids.

The Acids alſo ſuffer a conſiderable alteration by contracting an union with Oils. They become much milder, and loſe almoſt all their ſtrength. If the mixture deſcribed in the proceſs be diſtilled, there will come over a great quantity of an empyreumatic acidulated phlegm, that ſmells ſtrong of Sulphureous Spirit; an Oil thinner than the original ſaponaceous mixture; a weak oily Acid, and a very thick, black Oil. If the fire be made very ſtrong, when the Oil ceaſes to riſe, it ſometimes happens that a little Sulphur ſublimes into the neck of the retort.

By this analyſis it appears that the ſtrong concentrated Acid, which was an ingredient in the combination, is not now to be found. The Vitriolic Acid hath changed its nature, and is conſiderably weakened by the union it hath contracted with the principles of the Oil. The aqueous part of this latter ſubſtance weakens the other, and loads it with phlegm; the inflammable part thereof renders it ſulphureous, and even converts it into Sulphur.

Hence it follows that ſome part of the Oil is decompoſed, by the union it contracts with the Vitriolic Acid: for its phlogiſton and its aqueous principle cannot be diſunited, ſo as to form a Sulphureous Spirit, or an actual Sulphur, and an aqueous Acid, without the decompoſition of a certain quantity of the Oil, in proportion to the two disjoined principles. Another portion of the Oil remains united with the Vitriolic Acid, without ſuffering any decompoſition, and communicates to that portion of the Acid, with which it is ſo combined, a ſomewhat ſaponaceous quality, which makes it reſemble the vegetable Acids.

Thus we ſee, that, when the Vitriolic Acid and a Fat Oil are combined together, they both ſuffer conſiderable changes; the Acid by the new alliances into which it enters, and the Oil by the decompoſition it undergoes. In conſequence hereof a much ſmaller quantity of Oil is obtained, by decompounding this combination, than was at firſt put in.

If the Oil abſtracted by diſtillation be combined again with a freſh quantity of the concentrated Acid, the ſame effects will again follow; and by this means any quantity of Oil at pleaſure may be entirely decompoſed. This ſingle experiment affords an evident proof of many important truths advanced in our Elements of the Theory.

Spirit of Nitre likewiſe diſſolves expreſſed Oils. With Oil of Olives it forms a white paſte, reſembling a fine pomatum. This compound is perfectly ſoluble in Spirit of Wine. The Acid muſt be very ſtrong and ſmoking to unite with this, or with any other Fat Oil: but it diſſolves ſome of them with more rapidity than others; in which number is the Oil of Walnuts. It acts on theſe Oils with ſo much vehemence that it burns them, in ſome meaſure, making them black and thick.

PROCESS III.

To combine Fat Oils with Fixed Alkalis. Hard and Soft Soap. The decompoſition of Soap.

TAKE a lixivium of Alicant kelp made more cauſtic by lime, as we ſhall ſhew when we come to ſpeak of Alkalis. Evaporate this lye till it be capable of bearing a new-laid egg. Divide it nto two parts; and to one of theſe put juſt water enough to weaken it ſo that a new-laid egg will not ſwim in it, but fall to the bottom. With the lye thus weakened mix an equal quantity of freſh-drawn Olive Oil. Stir and agitate the mixture well till it become very white. Set it over a gentle fire, and continue ſtirring it inceſſantly, that the two ingredients of which it is compounded may gradually combine together, as part of the water evaporates. When you perceive they begin to unite, pour into the mixture thrice as much of the firſt ſtrong lye as you took of Olive Oil. Continue the coctionwith a gentle fire, always ſtirring the matter, till it become ſo thick that a drop of it fixes, as it cools, into the conſiſtence that Soap ought to have. By diſſolving a little of this Soap in water, you will diſcover whether or no it contains more Oil than ought to be in the compoſition. If it diſſolve therein wholly and perfectly, without the appearance of the leaſt little drop of Oil floating on the water, it is a ſign that it doth not contain too much Oil. If, on the contrary, you perceive any of theſe little globules, you muſt pour into the veſſel containing your matter a little more of the ſtrong lye, to abſorb the redundant Oil. If there be too much of the Alkali, it may be diſcovered by the taſte. If the Soap leave on your tongue the ſenſation of an Alkaline Salt, and produce an urinous ſavour, it is a ſign that there is too much Salt in proportion to the Oil. In this caſe a little Oil muſt be added to the mixture, to ſaturate the ſuper-abundant Alkali. An exceſs in the quantity of Alkali diſcovers itſelf likewiſe by the Soap's growing moiſt in the air, on being expoſed to it for ſome time.

OBSERVATIONS.

FIXED Alkalis, even when reſolved into a liquor, that is, when loaded with much water, unite eaſily with Fat Oils, as appears from the experiment juſt recited, and require but a moderate heat to perfect that union. This combination may even be completely effected without the aid of fire, and by the heat of the ſun only, provided ſufficient time be allowed for that purpoſe; as Mr. Geoffroy found upon trial. It only requires the mixture of the Oil and Alkali to be kept five or ſix days in digeſtion, and ſtirred from time to time. A lixivium of pure Alkali, not acuated by lime, may alſo be uſed to make Soap: but it is obſerved that the combination ſucceeds better, and that the Alkali unites ſooner and more perfectly with the Oil, when it is ſharpened by lime.

The Oil is firſt mixed with a weaker and more aqueous lye, to the end that the combination may not take place too haſtily, but that all the particles of the two ſubſtances to be compounded together may unite equally. But as ſoon as the Alkali begins to diſſolve the Oil gradually and quietly, the diſſolution may then be accelerated; and that is done by adding the remaining lye, which is ſtronger and leſs diluted than the other.

Soap made with Olive Oil is white, hard, and hath not a very diſagreeable ſmell: but as that Oil is dear, others, even the fat and oils of animals, are ſometimes ſubſtituted for it. The Soaps made with moſt of theſe other matters are neither ſo hard, nor ſo white, as that made of Olive Oil: they are called *Soft Soaps*.

Oils thus aſſociated with Fixed Alkalis are by that means rendered ſoluble in water; becauſe the Alkaline Salts, having a great affinity with water, communicate part thereof to the Oils with which they are now incorporated. Yet the Oil is not for all that rendered thoroughly miſcible with water or perfectly ſoluble therein; for the water in which Soap is diſſolved hath always a milky caſt: now there is no other criterion of a perfect ſolution but tranſparency.

Alkalis alſo loſe part of their affinity with water, by the union they thus contract with Oils: for, when the combination is properly made, they no longer attract the moiſture of the air, nor doth water diſſolve them in ſuch quantities as before. The compoſition of Soap is plainly a ſaturation of an Alkali with an Oil; and, in order to make perfect Soap, we are forced, as was ſaid in the proceſs, to grope, in a manner, by repeated trials, for this point of ſaturation; juſt as when we prepare a Neutral Salt by ſaturating an Alkali with an Acid. The union which the Oil contracts with the Alkali makes it loſe, in part, the readineſs with which it naturally takes fire; becauſe the Salt is not inflammable: the water alſo, which enters, in pretty conſiderable quantities, into the compoſition of Soap, as we ſhall preſently ſee, contributes a good deal to hinder the accenſion of the Oil.

Soap may be decompounded either by diſtilling it, or by mixing it with ſome ſubſtance that hath a greater affinity than Oil with Alkalis.

If we decompound it by diſtillation, a phlegm, or tranſparent ſpirit, of a ſomewhat yellowiſh colour, firſt comes over. This liquor is the aqueous part of the Soap, quickened by a little of its Alkali, which gives it an acrid taſte. It is followed by a red Oil, which at firſt is pretty thin and limpid, but thickens as the diſtillation advances, grows black, and has a very diſagreeable empyreumatic ſmell. This Oil is ſoluble in Spirit of Wine.

When the diſtillation is finiſhed, that is, when the retort being kept red-hot for ſome time will diſcharge no more, there is left in it a ſaline maſs; which is the Alkali of the Soap, cruſted over with ſome of the moſt fixed parts of the Oil, that are charred to a coal. This Salt may be reſtored to the ſame degree of purity it had before its combination with the Oil, by calcining it in a crucible with a naked fire, that may conſume this burnt part of the Oil, and reduce it to aſhes.

It is plain that the Oil contained in Soap is affected by diſtillation, much in the ſame manner as that which we mixed with lime and diſtilled.

Mr. Geoffroy, by analyſing Soap with care, diſcovered that two ounces thereof contain ninety ſix grains of Salt of kelp, freed from all Oil and moiſture; or two drams and forty-eight grains of that Salt, as it is uſed in manufacturing Soap; that is, containing water enough to make it cryſtallize; one ounce three drams twenty grains of Olive Oil; and about two drams four grains of water.

As Acids have a greater affinity than any other ſubſtance with Alkalis, they may be very effectually employed to decompound Soap.

If you propoſe to decompound Soap by means thereof, you muſt firſt diſſolve it in a ſufficient quantity of water. Mr. Geoffroy, who made this experiment likewiſe, diſſolved two ounces thereof in about three gallons of warm water, and to the ſolution added Oil of Vitriol, which he let fall into it drop by drop. Every time a drop of Acid falls into it, a *coagulum* is formed in the liquor. The veſſel in which the ſolution is contained muſt then be ſhaken, that the Acid may equally attack all the Alkali diffuſed in it. When no new coagulation is produced by a drop of the Acid, it is a ſign you have added enough. The liquor then begins to grow clear: and if another quart of water be added, in order to facilitate the ſeparation of the oily particles, you will ſee them riſe and unite together on the ſurface of the liquor.

This is a pure, clear, true Olive Oil, hath its taſte, its ſmell, and, like it, is fluid in warm weather and becomes fixed by cold. Yet it differs in ſome reſpects from that which never hath been united with an Alkali in order to form a Soap; for it burns more vividly and more rapidly, and is ſoluble in Spirit of Wine. We ſhall account for theſe differences when we come to treat of Ardent Spirits.

Not only the Vitriolic Acid, but all others, even thoſe obtained from vegetables, are capable of decompounding Soap, and ſeparating the Oil from the Alkali. In the liquor wherein Soap is thus decompounded is found a Neutral Salt, conſiſting of the

Acid made uſe of united with the Alkali of the Soap. If the Vitriolic Acid be uſed, you will have a Glauber's Salt; a quadrangular Nitre, if the Nitrous Acid be uſed; and ſo of the reſt.

The facility with which Acids decompound Soap is the reaſon that no water, but what is very pure, will diſſolve it, or is fit to be uſed in waſhing with it.

Water that doth not diſſolve Soap well is uſually called hard water. Such waters contain a certain quantity of ſaline matters, waſhed out of the earths through which they paſs. The hardneſs of water is generally occaſioned by ſelenitic particles.

The hardneſs of all the well-water in and about Paris is owing to a conſiderable quantity of Selenitic Gypſum with which the ſoil abounds. The Selenites, we know, are Neutral Salts conſiſting of the Vitriolic Acid united with an earthy baſis. If therefore Soap be put into water in which a Salt of this kind is diſſolved, it is evident that the Vitriolic Acid in the Selenites, having a greater affinity with the fixed Alkali of the Soap than with its own earthy baſis, will quit the latter to unite with the former; and thus the Soap will be decompounded inſtead of being diſſolved. Accordingly we ſee, that, when we attempt to diſſolve Soap in our well-water, the ſurface of the liquor is in a ſhort time covered with a fat oily pellicle. However, this decompoſition of Soap is not complete; at leaſt but a ſmall part of it is perfectly decompounded; becauſe the great quantity of Selenites, with which the water is impregnated, hinders the Soap from mixing ſo thoroughly with it, as is requiſite to produce a total decompoſition thereof.

All mineral waters are likewiſe hard, with regard to Soap; for, as moſt of them owe their virtues to the efflorefcencies they have waſhed off, from pyrites that have grown hot and begun to be decompoſed, they are impregnated with the ſaline matters produced by pyrites in that ſtate; that is, with aluminous, vitriolic, and ſulphureous ſubſtances, which have the ſame effect on Soap as the Selenites hath.

Mineral waters containing Neutral Salts only, ſuch as Sea-ſalt, Epſom-Salt, Glauber's Salt, are nevertheleſs hard with regard to Soap, though the Acids of thoſe Salts, being united with Fixed Alkalis, are incapable of decompounding it. The reaſon is, that thoſe Neutral Salts are more ſoluble in water than Soap is; ſo much indeed as even to exclude it: becauſe each of the two principles that compoſe them hath a very great affinity with water; whereas only one of the principles of Soap, namely its Alkali, hath that affinity; the other, to wit, the oily principle, having none at all. Thus water impregnated with an Acid, or with any Neutral Salt, is hard with regard to Soap, and incapable of diſſolving it; and hence it follows that Soap is a ſort of touchſtone for trying the purity of water.

Wine diſſolves Soap; but imperfectly, becauſe it contains an acid or tartarous part. Spirit of Wine alſo diſſolves it: but neither is this diſſolution perfect; becauſe it contains too little water: for its ſpirituous part can diſſolve nothing but the Oil of the Soap; and the Alkali is not at all, or at leaſt in a very ſmall quantity, ſoluble in this menſtruum. The true ſolvent of Soap is therefore a liquor that is partly ſpirituous, partly aqueous, and not acid.

Brandy has theſe qualities: and accordingly it is the ſolvent that unites beſt with Soap, diſſolves the greateſt quantity, and makes the moſt limpid ſolution thereof. Yet even this ſolution hath ſomething of a milky caſt, occaſioned by its not being entirely free from an Acid, or the tartarous principle. This fault may be eaſily corrected, by mixing with it a little Alkali to abſorb the Acid. A dram of cryſtallized ſalt of kelp mixed with three ounces and a half of good brandy, renders it capable of diſſolving an ounce and two drams of good hard Soap into a perfectly limpid liquor. This experiment alſo we owe to Mr. Geoffroy.

Some years ago it was diſcovered that Soap might be uſed with great ſucceſs in Medicine, and that it poſſeſſes the property of diſſolving the ſtony concretions that form in ſeveral parts of the body, particularly in the kidneys and bladder. Soap is the baſis of the compoſition known by the name of *Mrs. Stephens*'s *Remedy*; and in this one ingredient its whole virtue reſides.

From what hath been ſaid on the nature of this compound, as well as on the cauſe and phenomena of its diſſolution, it plainly appears to be of the laſt conſequence, in adminiſtering it to a patient, that his conſtitution be conſidered, and a proper regimen ordered. All Acids ſhould be abſolutely forbid him; as we know they hinder the Soap from diſſolving, and decompound it: and if the patient have any acidities in the firſt paſſages, matters capable of neutralizing them ſhould be preſcribed him; as prepared crabs eyes, and other abſorbents known in Medicine: In ſuch caſes thoſe with which the Soap is compounded in Mrs. Stephens's remedy may be of uſe.

PROCESS IV.

To combine Fat Oils with Sulphur.

PUT any Fat Oil whatever into an earthen veſſel; add to it about a fourth part of its weight of Flower of Sulphur, and ſet the veſſel in a furnace, with lighted coals under it. When the Oil hath acquired a certain degree of heat, the Sulphur will melt, and you will ſee it fall immediately to the bottom of the Oil, in the form of a very red fluid. The two ſubſtances will remain thus ſeparated, without mixing together, while the heat is no greater than is neceſſary to keep the Sulphur in fuſion. Increaſe it therefore; but ſlowly and with circumſpection, leſt the matter take fire. When the Oil begins to ſmoke, the two liquors will begin to mix and look turbid: at laſt they will unite ſo as to appear one homogeneous whole. If you keep up the heat ſo that the mixture ſhall always continue ſmoking and ready to boil, you may add more Sulphur, which will perfectly incorporate with it: and thus may a pretty conſiderable quantity thereof be introduced into this compoſition.

OBSERVATIONS.

THE Phlogiſton and the Vitriolic Acid have each an affinity with Oils. It is not therefore ſurpriſing that Sulphur, which is a compound of theſe two ſubſtances, ſhould be ſoluble in oily matters. Yet it is remarkable that Eſſential Oils, which are much thinner than the Fat Oils, diſſolve Sulphur with much more difficulty; as will be ſhewn when we come to treat of thoſe Oils; and that Spirit of Wine, which contains an exceeding ſubtile Oil, doth not act upon Sulphur at all.

Oil, by contracting an union with Sulphur, produces a conſiderable alteration in that mineral: a phenomenon ſo much the more ſurpriſing, that we know it to be, in ſome ſort, unalterable by any other ſolvent, of what kind ſoever, and that its nature admits of no change but by burning. We ſhall ſay more on this ſubject under the head of Eſſential Oils.

PROCESS V.

To combine Fat Oils with Lead, and the Calxes of Lead. The Baſis of Plaſters. The Decompoſition of this Combination.

INTO an earthen veſſel put granulated Lead, Litharge, Ceruſe, or Minium; and pour thereon twice its weight of any Fat Oil whatever. If you ſet the veſſel over a briſk fire, the Lead at bottom will melt before the Oil begin to boil. When it boils, ſtir the matter with a ſtick: the Lead or the Calx of Lead will gradually diſappear, and at laſt be totally diſſolved by the Oil, to which it will give a very thick conſiſtence.

OBSERVATIONS.

FAT Oils diſſolve not only Lead, but its calxes alſo: nay, they diſſolve the latter more readily than Lead in ſubſtance; probably becauſe they are more divided. The reſult of a combination of theſe matters is a thick, tenacious maſs, that grows in ſome degree hard in the cold, and ſoft by heat. This compoſition is known in Pharmacy by the name of *Plaſter*. It is made up with ſeveral drugs into plaſters, which partake of the virtues of thoſe drugs; ſo that it is the baſis of almoſt all plaſters.

Lead itſelf is ſeldom uſed to make plaſters: Ceruſe, Litharge, or Minium are preferred to it; becauſe theſe matters unite, as hath been ſaid, more readily and more eaſily with Oils.

It ſometimes happens that the Oil is burnt in the operation, and that the calx of Lead is partly reſuſcitated: and this gives the plaſter a black colour, which it ought not always to have. This accident is occaſioned by an exceſs of heat: and as it is very difficult to keep the Oil and the Lead in the proper degree of heat, ſeeing both theſe matters are apt to grow very hot, it hath been contrived to put into the veſſel, in which the coction is to be performed, a pretty large quantity of water; which being ſuſceptible only of a much ſmaller and a certain degree of heat, that is conſtantly the ſame when it boils, procures the advantage of having the compoſition very uniform, and very white.

It is neceſſary to ſtir the mixture inceſſantly, in order to prevent the burning of the combined Oil and Lead; which, as they unite, ſink in the water by their greater weight. If the water happen to be waſted before the Oil hath diſſolved all the Lead, or before the plaſter hath acquired a proper degree of conſiſtence, you muſt remove the veſſel from the fire, and let the mixture cool, before you add more: for, if this precaution be neglected, the heat of the matter, which is now much greater than that of boiling water, will occaſion a conſiderable exploſion and extravaſation thereof, though the water poured into it be as hot as poſſible.

The combination of Fat Oil with a Calx of Lead may be conſidered as a ſort of metallic Soap, having a metalline Calx, inſtead of a Fixed Alkali, for its baſis. Mr. Geoffroy hath obſerved that if a pound of Litharge, rubbed very fine and well waſhed, be incorporated with two pounds of Olive Oil, in the ſame manner as plaſter is made, keeping water enough in the veſſel to hinder the mixture from burning, there riſes a ſmoke, while the Oil is uniting with the Calx of Lead, ſmelling much like that which riſes from Soap.

The Oil may be ſeparated from the Calx of Lead, by the methods uſed to ſeparate it from a Fixed Alkali: and when it is ſo ſeparated, it hath the ſame properties as that ſeparated from common Soap.

This ſpecies of metallic Soap, formed by the union of a Fat Oil with the Calx of Lead, is not ſoluble in water, and communicates nothing to it but a greaſy taſte. Therefore, if you would decompound it by the means of an Acid, you muſt pour that Acid immediately on the compound. The Acid will attack and diſſolve the Calx of Lead; and the Oil, being thus ſet at liberty, will riſe clear and limpid to the ſurface of the acid liquor. Diſtilled vinegar effects this ſeparation better than any other Acid, becauſe it is the true ſolvent of Lead.

CHAP. IV.

OF THE SUBSTANCES OBTAINED FROM VEGETABLES WITH a DEGREE OF HEAT NOT EXCEEDING THAT OF BOILING WATER.

PROCESS I.

To obtain from Plants, by diſtilling them with the mean degree of heat between freezing and boiling water, a liquor impregnated with their Principle of Odour.

IN the morning, before ſun-riſe, gather the plant from which you deſign to extract its odoriferous water. Chuſe the plant in its full vigour, perfectly ſound, and free from all adventitious matters, except dew. Put this plant, without ſqueezing it, into the body of a tinned copper alembic, and ſet it in a water-bath. Fit on its head, and to the noſe thereof lute a glaſs receiver with wet bladder.

Warm the bath to the mean degree between freezing and boiling water. You will ſee a liquor diſtill and fall drop by drop into the receiver. Continue the diſtillation with this degree of heat, till no more drops fall from the noſe of the alembic. Then unlute the veſſels; and if you have not as much liquor as you want, take out of the cucurbite the plant already diſtilled, and put a freſh one in its place. Diſtill as before, and go on thus till you have a ſufficient quantity of odoriferous liquor. Put it into a bottle; ſtop it cloſe; and ſet it in a cool place.

OBSERVATIONS.

THE liquor obtained from plants, with the degree of heat here preſcribed, conſiſts of the dew that was on the plant, and ſome of the phlegm of the plant itſelf, together with its odorous principle. Mr. Boerhaave, who examined this odoriferous part of plants with great care, calls it the *Spiritus Rector.* The nature of this Spirit is not yet thoroughly aſcertained; becauſe it is ſo very volatile, that it cannot eaſily be ſubjected to the experiments that are neceſſary to analyze it, and to diſcover all its properties. If the bottle containing the liquor, which may be conſidered as the vehicle of this Spirit, be not exceeding carefully ſtopped, it flies quite off: ſo that in a few days nothing will be found but an inſipid inodorous water.

Great part of the virtue of plants reſides in this their principle of odour; and to it muſt be aſcribed the moſt ſingular and the moſt wonderful effects we every day ſee produced by them. Every body knows that a great number of odorous plants affect, in a particular manner, by their ſcent only, the brain and the *genus nervoſum*, of ſuch eſpecially whoſe nerves are very ſenſible, and ſuſceptible of the ſlighteſt impreſſion; ſuch as hypochondriacal or melancholy men, and hyſterical women. The ſmell of the Tuberoſe, for inſtance, is capable of throwing ſuch perſons into fits, ſo as to make them drop down and ſwoon away. The ſmell of Rue again, which is equally ſtrong and penetrating, but of a different kind, is a ſpecific remedy againſt the ill effects of the Tuberoſe; and brings thoſe perſons to life again, with as quick and as ſurpriſing an efficacy as that by which they were reduced to a ſtate not unlike death. This is Mr. Boerhaave's obſervation.

The odorous exhalations of plants muſt be conſidered as a continual emanation of their *Spiritus Rector:* but as growing plants are in a condition to repair, every inſtant, the loſſes they ſuſtain by this means, as well as by tranſpiration, it is not ſurpriſing that they are not ſoon exhauſted while they continue in vigour. Thoſe, on the contrary, which we diſtill, having no ſuch reſſource, are very ſoon entirely exhauſted of this principle.

The ſeparation of the *Spiritus Rector* from plants requires but a very gentle heat, equally diſtant from the freezing point, and from the heat of boiling water. Accordingly the heat of the ſun in ſummer is ſufficient to diſſipate it almoſt entirely. This ſhews why it is dangerous to ſtay long in fields, or woods, where many noxious plants grow. The virtues of plants reſiding chiefly in their exhalations, which the heat of the ſun increaſes conſiderably, a ſort of atmoſphere is formed round them, and carried by the air and the wind to very great diſtances.

For the ſame reaſon the air of a country may be rendered ſalutary and medicinal, by the exhalations of wholeſome plants growing therein. From the facility with which the odorous principle of plants evaporates, we learn what care ought to be taken in drying thoſe intended for medical uſes, ſo as to preſerve their virtues. They muſt by no means be expoſed to the ſun, or laid in a warm place: a cool, dry place, into which the rays of the ſun never penetrate, is the propereſt for drying plants with as little loſs of their virtue as poſſible.

Though there is reaſon to believe that every vegetable matter hath a *Spiritus Rector*, ſeeing each hath its particular ſcent, yet this principle is not very perceptible in any but thoſe which have a very manifeſt odour: and accordingly it is extracted chiefly from aromatic plants, or the moſt odoriferous parts of plants. I ſay the moſt odoriferous parts; becauſe in moſt plants and trees there are generally certain parts that have a much more ſenſible and much ſtronger ſcent than the reſt. The odour of a plant or of a tree hath its principal reſidence ſometimes in the root, ſometimes in the leaves, at other times in the bark or wood, and very frequently in the flowers and ſeeds. Therefore, when you deſign to extract the principle of odour from a vegetable that is not equally odoriferous in every part, you muſt chuſe thoſe parts that have the moſt perceptible and ſtrongeſt ſcent.

PROCESS II.

To extract the Fat Oils of Plants by Decoction in boiling Water. Cacao-Butter.

POUND or bruiſe in a marble mortar your vegetable ſubſtances abounding with the Fat Oil which you intend to extract by decoction: tie them up in a linen cloth: put this packet into a pan, with ſeven or eight times as much water, and make the water boil. The Oil will be ſeparated by the ebullition, and float on the ſurface of the water. Skim it off carefully with a ladle, and continue boiling till no more Oil appear.

OBSERVATIONS.

THE heat of boiling water is capable of ſeparating the Fat Oils from vegetable matters that contain any: but this is to be effected by actual decoction only, and not by diſtillation; becauſe theſe Oils will not riſe in an alembic with the heat of boiling water. We are therefore neceſſitated to collect them from the ſurface of the water, as above directed. By this means a much greater quantity of Fat Oil may be obtained than by expreſſion alone; becauſe the degree of heat applied greatly facilitates the ſeparation of the Oil. For a convincing proof of this truth, take the remains of any vegetable matters, from which the Oil hath been ſo thoroughly expreſſed that they would yield no more; boil them in this manner, and you will obtain a great deal more Oil.

The water uſed in this coction generally becomes milky, like an emulſion; becauſe it contains many oily particles, that are diſperſed in it juſt as in an emulſion. Nevertheleſs this way of obtaining the Fat Oils is not generally practiſed; becauſe the heat, to which they are expoſed in the operation, occaſions their being leſs mild than they naturally are: but it is an excellent method, and indeed the only one that can be employed, for extracting from particular vegetables certain concrete oily matters, in the form of Butter or Wax; which matters are no other than Fat Oils in a fixed ſtate. The Cacao yields, by this means, a very mild Butter; and in the ſame manner is a Wax obtained from a certain ſhrub in America.

The heat of boiling water melts theſe oily matters, which then aſcend to the ſurface of the liquor, and float on it like other Oils. They afterwards fix as they cool, and reſume their natural conſiſtence. We ſhall ſee in the ſequel that they cannot be extracted in a concrete form by diſtillation, which requires a greater degree of heat than that of boiling water; becauſe diſtillation changes their nature, partly decompoſes them, and prevents their returning to their proper conſiſtence as they cool.

PROCESS III.

To extract the Eſſential Oils of Plants by diſtillation with the beat of boiling water. Diſtilled waters.

PUT into a cucurbite the plant from which you deſign to extract the Eſſential Oil. Add as much water as will fill two thirds of your veſſel, and diſſolve therein half an ounce of Sea-ſalt for every quart of water you uſe. To this body fit on an alembic head, and to the noſe thereof lute a receiver with ſized paper or wet bladder. Set it in a furnace, and let the whole digeſt together, in a very gentle warmth, for twenty four hours.

This being done, light a wood-fire under your veſſel, briſk enough to make the water in it boil immediately. Then ſlacken your fire, and leave it juſt ſtrong enough to keep the water ſimmering. There will come over into the receiver a liquor of a whitiſh colour, ſomewhat milky; on the ſurface of which, or at the bottom, will be found an Oil, which is the Eſſential Oil of the vegetable you put into the cucurbite. Continue your diſtillation with the ſame degree of heat, till you perceive the liquor come off clear, and unaccompanied with any Oil.

When the diſtillation is finiſhed, unlute the receiver; and, if the Eſſential Oil be of that ſort that is lighter than water, fill the veſſel up to the top with water. On this occaſion a long-necked matraſs ſhould be uſed for a receiver; that the Oil which floats on the water may collect together in its neck, and riſe up to its mouth. Then in the neck of this veſſel put the end of a thread of cotton-twine, ſo that the depending part without the veſſel may be longer than that in the Oil, and the extremity thereof hang within the mouth of a little phial, juſt big enough to contain your quantity of Oil. The Oil will riſe along the yarn as in a ſiphon, filter through it, and fall drop by drop into the little phial. When all the Oil is thus come over, ſtop your little bottle very cloſe, with a cork coated over with a mixture of wax and a little pitch.

If your Oil be ponderous, and of the ſort that ſinks in water, pour the whole contents of the receiver into a glaſs funnel, the pipe of which muſt terminate in a very ſmall aperture that may be ſtopped with your fore-finger. All the Oil will be collected in the lower part of the funnel: then remove your finger, and let the Oil run out into a little bottle through another ſmall funnel. When you ſee the water ready to come, ſtop the pipe of the funnel, and cork the bottle containing your Oil.

OBSERVATIONS.

ESSENTIAL Oils, though they all reſemble each other in their principal properties, are nevertheleſs very different in ſome reſpects: for which reaſon almoſt every one of them requires a particular management, for obtaining it with the greateſt advantage poſſible, both as to quality and quantity.

One of the firſt things requiſite is to chuſe the proper time for diſtilling the plant from which you deſire to extract the Eſſential Oil; becauſe the quantity of Oil varies conſiderably, according to the ſeaſon of the year, as well as the age of the plant. For example, the moſt favourable time for obtaining theſe Oils from the leaves of ever-green plants or trees, ſuch as Thyme, Sage, Roſemary, the Orange, the Bay, the Fir, &c. is the end of autumn; becauſe theſe vegetables contain a great deal more Oil at that ſeaſon than at any other. With regard to annual plants, they muſt be choſen when in their prime, and juſt before they begin to decline. The time therefore of gathering them is when they begin to flower: and if you want to extract the Oil from the flowers themſelves, you muſt pull them juſt when they are newly blown.

Secondly, it muſt be obſerved that the Eſſential Oils of plants are, as it were, the chief reſidence and reſervoir of their odorous principle; that they are to be found wherever that principle exiſts, and never where it is not: ſo that what we ſaid concerning the *Spiritus Rector* of plants is applicable here. It muſt be remembered that all the parts of ſome vegetables are odoriferous. Such plants may be put into the alembic all together, and the Eſſential Oil diſtilled from all their parts at once. But others, and indeed the greateſt number, have no odour, or at leaſt none that is very perceptible, except in ſome particular parts; as in their leaves, flowers, roots, or ſeeds: therefore, when you want to have the Eſſential Oil of ſuch a plant, you muſt chuſe that part in which the odour reſides. The ſenſe of ſmelling muſt be the Artiſt's principal guide on this occaſion.

Thirdly; all vegetables, and all the parts of vegetables, have not the ſame texture: ſome are hard and compact, as woods, barks, and ſome roots; others are tender and ſucculent, as moſt annual plants and ſome fruits. For this reaſon they muſt be differently prepared for diſtillation. It may be laid down as a general rule, that, the cloſer and more compact their texture is, the more they require to be opened and divided, either by comminuting them into ſmall particles, or by digeſting them a conſiderable time in water acuated with Salt.

Fourthly; though all Eſſential Oils be capable of riſing in diſtillation with the heat of boiling water, yet they have not all an equal degree of levity and weight: on the contrary, they vary exceedingly in this reſpect: ſome, as for inſtance thoſe of all our European aromatics, being lighter than water, ſo that they always float on its ſurface; whereas others, ſuch as thoſe of Cloves, Saſſafras, &c. which are Indian aromatics, are heavier than water, and always ſink in it by their ſpecific gravity. Theſe differences therefore require different meaſures in diſtillation. It is proper, for example, to make uſe of a low alembic in diſtilling ſuch Eſſential Oils as are heavier than water; and moreover, to facilitate their ſeparation by applying a degree of heat ſomewhat ſtronger than that of boiling water. This is eaſily done by impregnating the water with a proper quantity of Sea-Salt, or the Vitriolic Acid; for, the more ſaline matters are contained in water, the more will the degree of heat it acquires by being brought to boil exceed that of pure boiling water.

Fifthly; Eſſential Oils differ from one another in point of fluidity. Some are as thin and as fluid as Spirit of Wine: of this number is the Eſſential Oil of Turpentine. Others again are thick, and even congeal as they cool: ſuch, for inſtance, is the Oil of Roſes. In diſtilling Oils of this latter ſort, care muſt be taken that the ſpout of the alembic-head grow not too cold, but be kept always in ſuch a degree of warmth, as may prevent the Oil from fixing in it, and ſtopping it up; which would interrupt the diſtillation, and might alſo occaſion ſome other more conſiderable inconveniences, of which we ſhall take notice preſently.

From what hath been ſaid it appears that the diſtillation of Eſſential Oils cannot be regulated by any one general rule; but that the manner of operating muſt be a little varied, according to the nature of the Oil to be diſtilled, and to that of the vegetable from which it is to be drawn.

The time of day fitteſt to gather plants for this diſtillation, is the morning before ſun-riſe; becauſe the coolneſs of the night hath ſhut all their pores, and concentrated their odour: whereas in the evening, after the plants have been expoſed all day to the heat of the ſun, their odorous principle is in a great meaſure diſſipated, and they are left almoſt quite exhauſted of it. Now, the more of the odorous principle the plants contain, the more Eſſential Oil will they yield, and the more virtue will that Oil have.

Plants freſh gathered, and as yet full of moiſture, do not yield ſo much Oil in diſtillation as they do when dried; becauſe the Oily particles in a very moiſt plant are more diffuſed, and even ſeparated from each other, by the interpoſition of the aqueous parts: whence it come to paſs that in diſtillation they aſcend in a ſtate of ſeparation from each other, ſo that being diſperſed through the water they give it a milky colour, like that of an emulſion, and cannot unite together but in ſmall quantities; which hinders their being eaſily ſeparated from the water.

This inconvenience doth not happen, or at leaſt is conſiderably leſs, when the greateſt part of the humidity of the plant is evaporated by deſiccation: for the oily particles, being thus delivered from the intervening aqueous parts, which kept them ſeparated from each other, are brought nearer together, unite, and form little viſible globules of Oil, which eaſily emerge from the water employed in the diſtillation. But, in drying plants from which the Eſſential Oil is to be extracted, great care muſt be taken that they be neither expoſed to the ſun, nor laid in a warm place; becauſe the heat would carry off part of their odour, and even, from ſome plants, a pretty conſiderable quantity of their Eſſential Oil.

Plants of a looſe texture, that eaſily give out their Eſſential Oils, need not be comminuted, or macerated in water with Salt. But this method muſt unavoidably be taken with ſuch as are hard, and do not readily part with their Oil. Woods, barks, roots, for inſtance, muſt be firſt raſped, then ſet to macerate in water impregnated with Salt, as before directed; and this ſometimes for ſeveral weeks before they be diſtilled.

On this occaſion Salt procures three different advantages. In the firſt place, it prevents the matters, that muſt ſtand in maceration for ſome time, from running into fermentation: an inconvenience that would conſiderably diminiſh the quantity of Eſſential Oil, or perhaps rob us of the whole, by converting it into an Ardent Spirit, if the fermentation were ſpirituous; or into a Volatile Alkali, if it went on to the laſt ſtage, and as far as putrefaction. In the next place, it acuates the water, and renders it more capable of penetrating and properly dividing, during the maceration, the texture of the plant which requires to be thus prepared. Laſtly, it adds a little to the heat of the boiling water, and ſo promotes the aſcent of the heavieſt Oils.

Nevertheleſs, when you find it neceſſary, for the reaſons aſſigned above, to mix Salt with the water to be employed in diſtilling your Eſſential Oil, you muſt be cautious of putting in too much. You will indeed obtain, by means thereof, much more Oil than if you diſtilled it without Salt: but, as a great quantity of Salt will make the water acquire a much greater degree of heat, than that of pure boiling water, a good deal of the heavy Oil of the vegetable will be raiſed by ſuch a heat, mix with the Eſſential Oil, deprave it, and make it like thoſe that are adulterated with a mixture of ſome heterogeneous Oil, as will be afterwards ſhewn.

When every thing is prepared for diſtillation, it is proper, as directed in the proceſs, to apply at once a flaming fire, briſk enough to make the liquor boil immediately: for, if the water be kept long heating before it be made to boil, the Eſſential Oil, which cannot riſe without the heat of boiling water, will, by a leſs degree of heat, be only agitated, daſhed about every way, and churned as it were; by which means it will be divided into very minute particles, and diſperſed in the water, which will thence acquire a milky colour: and conſequently we ſhall fall into the inconvenience that was pointed out above, as happening when we diſtill plants without having dried them, and while they are loaded with all the moiſture and ſap that was in them when freſh gathered.

When the water in the cucurbite boils, it will be known by the noiſe that boiling water uſually makes, which is produced by the numerous bubbles that riſe and burſt on its ſurface. The ſpout of the alembic is then ſo hot, that a man cannot lay his finger on it without ſuch a ſenſation of burning heat as cannot be endured. With this degree of heat the water diſtills in drops, which ſucceed each other ſo faſt that they ſeem to form a continued ſmall ſtream, and this water is replete with much Eſſential Oil.

And now it is proper to weaken the fire conſiderably, ſo as to leave it but juſt ſtrong enough to keep the liquor gently boiling: for if the diſtillation be urged too precipitately, the aqueous and oily vapours, being forcibly hurried up by too great a heat, may carry along with them ſome parts of the plant, which may ſtick in the ſpout, ſtop it up, and endanger the burſting of the veſſel, or at leaſt the forcing off its head, by the exceedingly rarefied particles of water, oil, and air, all ſtriving to eſcape at the ſame time; and theſe burning hot vapours, being diſcharged with impetuoſity, may not only ſcald the Operator, but injure his lungs.

In ſuch diſtillations it is of conſequence to keep conſtantly cooling the head of the alembic by frequently renewing the water in the refrigeratory, in order to facilitate the condenſation of the oily particles,

cles. The water in the cooler ought to be renewed when it begins to ſmoke very perceptibly.

Whatever care be taken to ſave as much of the Oil as poſſible, and to prevent its being left diſperſed in the water, yet ſome loſs of this kind cannot be totally avoided: and thus the water that riſes in diſtilling the Oil is always more or leſs milky, and ſtrongly ſcented, even after it is ſeparated from the Eſſential Oil. Yet this portion of the Oil and of the odorous principle, which is retained by the water employed in ſuch diſtillation, is not therefore loſt: the water impregnated with theſe principles partakes of the properties of the plant from which the Eſſential Oil was drawn, and may be uſed medicinally: it is known in Pharmacy by the title of the *Diſtilled Water* of the plant.

The ſame water may be uſed again, with advantage, in diſtilling the Eſſential Oil of a freſh plant of the ſame ſort; becauſe the oily and odorous particles, with which it is impregnated, joining with thoſe afforded by the freſh plant, form larger *moleculæ*, capable of uniting more eaſily, and emerging better from the water; and conſequently they increaſe the quantity of Oil. Thus the ſame water may be always employed in new diſtillations; and, the oftener it is uſed, with the greater advantage may it be uſed again.

After all the Eſſential Oil is riſen, if the diſtillation be continued, and the receiver changed, the liquor that will then come off will not be milky, but limpid. It will have no odour at all of the plant, but a kind of ſouriſh ſmell; and indeed it is a part of the Acid of the vegetable in the ſtill, which is elevated by the heat of boiling water, after all the Eſſential Oil is come over.

If you intend to keep the diſtilled water which hath ſerved as a vehicle to the Eſſential Oil, and deſign it for medicinal uſe, great care muſt be taken to ſtop the diſtillation before this acid phlegm begin to riſe: for, if it ſhould mix with the diſtilled water, it would ſpoil it, and hinder it from keeping; probably becauſe it contains ſome mucilaginous parts, which are apt to putrify.

PROCESS IV.

To extract the Eſſential Oils of Plants by diſtillation per deſcenſum.

REDUCE to a powder, or a paſte, the vegetable ſubſtances from which you intend to extract the Eſſential Oil by the method propoſed. Lay this matter about half an inch thick on a fine, cloſe, linnen cloth. If it be dry and hard, expoſe the cloth containing it to the ſteam of boiling water, till the matter become moiſt and ſoft. Then lay the cloth, with its contents, over the mouth of a very tall cylindrical glaſs veſſel, which is to do the office of a receiver in this diſtillation; and, by means of a piece of ſmall pack-thread, faſten down the extremities of the cloth, by winding the thread ſeveral times over them and round the veſſel; in ſuch a manner, however, that the cloth be not tight, but may yield to a ſmall weight, and ſink about five or ſix lines deep into the veſſel over which it is faſtened. Set this recipient in a larger veſſel, containing ſo much cold water as will reach half way up the cylindrical veſſel, which, having little in it but air, muſt be ballaſted with as much lead as will ſink it to the bottom of the water.

On the cloth containing the ſubſtance to be diſtilled ſet a flat pan of iron or copper, about five or ſix lines deep, that may juſt fit the mouth of the glaſs veſſel over which the cloth is faſtened, ſo as to ſhut it quite cloſe. Fill this pan with hot aſhes, and on theſe lay ſome live coals. Soon after this you will ſee vapours deſcend from the cloth, which will fill the recipient, and drops of liquor will be formed on the underſide of the cloth, from whence they will fall into the veſſel. Keep up an equal gentle heat, till you perceive nothing more diſcharged. Then uncover the recipient: you will find in it two diſtinct liquors; one of which is the phlegm, and the other the Eſſential Oil of the ſubſtance diſtilled.

OBSERVATIONS.

THE apparatus for diſtilling above deſcribed is very convenient, when we have not the veſſels neceſſary for diſtilling with water, or when we want to obtain the Eſſential Oil of any vegetable ſubſtance in much leſs time. The aqueous and oily parts of the ſubſtances diſtilled in this manner, being rarefied by the heat of the fire placed over them, cannot aſcend upwards, becauſe they are cloſe confined on that ſide; and moreover, the fire which rarefies them poſſeſſing all the upper part of the veſſel in which they are contained, they are forced to fly from it to the place which moſt favours their condenſation: and this determines them to deſcend in the recipient, where they meet with a coolneſs that condenſes and fixes them. It was with a view to promote this condenſation that we ordered the lower part of the recipient to be ſunk in cold water.

Cloves are one of thoſe ſubſtances whoſe Eſſential Oil is beſt obtained by this method. In the ſame way alſo may be drawn the Eſſential Oil of Lemon-peel, Citron-peel, Orange-peel, Nutmegs, and ſeveral other vegetable ſubſtances: but you muſt be cautious of applying too ſtrong a heat; for in that caſe the Oil, inſtead of being white and limpid, acquires a red, dark-brown, blackiſh colour, is burnt, and ſmells of empyreuma: and, on the other hand, if you do not apply a proper degree of heat, you will ſcarce get any Oil at all. It is the ſureſt and therefore the beſt way to diſtill theſe Oils with water in an alembic. And indeed the diſtillation *per deſcenſum* is ſeldom uſed but out of curioſity to try its effect, or on ſuch preſſing occaſions as allow no choice.

PROCESS V.

Infuſions, Decoctions, and Extracts of Plants.

MAKE ſome water boiling-hot, and then take it off the fire. When it ceaſes to boil, pour it on the plant of which you deſire to have the Infuſion; taking care there be enough of it to cover the plant entirely. Cover the veſſel, and let your plant ly in the hot water for the ſpace of half an hour, or longer if it be of a firm cloſe texture. Then pour off the water by inclination: it will have partly acquired the colour, the ſmell, the taſte, and the virtues of the plant. This liquor is called an *Infuſion*.

To make the Decoction of a vegetable ſubſtance, put it into an earthen pan, or into a tinned copper veſſel, with a quantity of water ſufficient to bear being boiled for ſeveral hours without leaving any part of the plant dry. Boil your plant more or leſs according to its nature; and then pour off the water by inclination. This water is impregnated with ſeveral of the principles of the plant, of which we ſhall take notice in the following obſervations.

OBSERVATIONS.

WATER, eſpecially when boiling-hot, is capable of diſſolving not only all that is purely ſaline in vegetables, but alſo a pretty conſiderable quantity of their Oil and of their earth, which, by contracting an union with the ſaline parts, have formed ſaponaceous, gummy, and mucilaginous compounds that are ſoluble in water. After violent and long continued boiling, therefore, there remains nothing in the plant but the pureſt oily part, and ſuch as is the moſt fixed, that is, the moſt cloſely united with the earth of the plant. I ſay the moſt fixed; for ſome part of the oily matters, though not ſoluble in water, may be ſeparated by the action of boiling water, when thoſe matters abound greatly in the vegetable decocted; as we have ſeen happen to the Fat Oils of certain vegetable matters; but in that caſe theſe oily matters float upon the Decoction, and do not conſtitute a part of it.

From what we have already ſaid touching the analyſis of plants it ſeems evident, that, if thoſe decocted be odoriferous and contain an Eſſential Oil, the Decoction will contain none, or at moſt but very little, of their Eſſential Oil, or their odorous principle; ſeeing we know that theſe ſubſtances cannot bear the heat of boiling water, without being carried off and entirely diſſipated by it. Therefore, when we make a Decoction of an aromatic plant containing an Eſſential Oil, we may be aſſured that it will not poſſeſs the virtues, either of the odorous part, or of the Eſſential Oil, and that it will have none but thoſe of the other more fixed principles of the plant with which it may be impregnated. The Decoction of ſuch a plant perfectly reſembles the water left in the cucurbite, after diſtilling its Eſſential Oil. But for thoſe plants in which there are no ſuch volatile parts, or whoſe virtue doth not reſide in thoſe principles, ſuch as aſtringent and emollient plants, for example, that owe their properties wholly to an earthy Salt, or to a mucilage, they are capable of communicating their whole virtue to the water in which they are infuſed or decocted.

If, on one hand, the Salts of plants render ſome portion of the principles of thoſe plants ſoluble in water, ſuch as part of their Oil and their earth, which if they were pure would not diſſolve therein; on the other hand theſe principles, being of their own nature indiſſoluble in water, hinder the Salts, by the union they have contracted together, from diſſolving in it ſo eaſily, ſo ſoon, and in ſuch quantities as if they were pure. This is ſo true that water, though boiled long and violently, is far from extracting out of plants all thoſe parts that it is capable of diſſolving. If, after boiling a plant in water, as directed in the proceſs, this water be poured off, freſh water added, and a ſecond decoction made in the ſame manner as the firſt, the water of this latter decoction will by that means be almoſt as ſtrongly impregnated with the principles of the plant as the former was. Mr. Boerhaave was obliged to make twenty ſucceſſive decoctions of the ſame plant, to wit, Roſemary, before the water came off the plant colourleſs and inſipid; in a word, juſt as it was before the plant was boiled in it.

Mr. Boerhaave obſerves that a plant, after having thus given out all that water can diſſolve, ſtill retains exactly the ſame form that it had before it underwent any of the many boilings neceſſary to exhauſt it; that its colour, from being green at firſt, becomes brown; and that the plant, which when green is lighter than water, or at leaſt doth not ſink in it, is heavier after this operation, and falls to the bottom. This is a proof that the water hath extracted out of the plant its lighteſt ſubſtances, aſſuming their places itſelf, and that it hath left nothing but its heavieſt principles, namely its fixed oil and its earth. We ſhall afterwards examine more particularly theſe remains of plants exhauſted by water.

If the Infuſions and Decoctions of plants be filtered, and evaporated in a gentle heat, they become Extracts, that may be kept for whole years, eſpecially if they be evaporated to a thick conſiſtence; and better ſtill if they be evaporated to dryneſs.

From what hath been ſaid concerning the Infuſions, Decoctions, and Extracts of plants, it follows 1. that Infuſions and Decoctions of aromatic plants do not furniſh a complete Extract of thoſe plants; becauſe they do not contain the volatile and odorous parts, in which the principal virtue of ſuch plants uſually reſides. If therefore you deſire to make Extracts of ſuch vegetables, that ſhall have no defect, you muſt employ their juices drawn by expreſſion, or water impregnated with their principles by the means of trituration, and evaporate the liquor by ſpreading it over a great number of plates, in order to enlarge its ſurface, and quicken the evaporation, which muſt be effected by the heat of the ſun alone, or the well-tempered warmth of a ſtove,

2. It may alſo be inferred that water alone, aided by the degree of heat it is capable of acquiring by being made to boil, is not ſufficient to effect the complete analyſis of a plant; ſince not only ſome of its principles are ſtill left combined in it, though exhauſted as much as it can be by boiling water; but alſo ſeveral of the ſubſtances extracted from it by water are compounds of ſome of the principles of the plant, and ſuſceptible of a much more accurate analyſis; as we ſhall be convinced when we come to examine the effects which a degree of heat ſuperiour to that of boiling water is able to produce on entire plants, on their Extracts, and on their remains exhauſted as much as they can be by boiling water.

But before we enter on that part of the analyſis, it is proper to conſider the experiments and combinations that may be made with the principles we have already obtained; in order to diſcover their nature, and in ſome meaſure analyze even them. Eſſential Oils in particular deſerve to be thus examined.

We alſo obtain from certain plants, with a degree of heat leſs than that of boiling water, a Volatile Alkali, which exiſts formally in them: but as theſe plants when analyzed yield principles different from thoſe we obtain out of all other vegetable ſubſtances, and as they reſemble animal matters, we ſhall refer their analyſis to a diſtinct Chapter.

CHAP. V.

OF OPERATIONS ON ESSENTIAL OILS.

PROCESS I.

The Rectification of Eſſential Oils.

PUT into a cucurbite the Eſſential Oil you propoſe to rectify. Set the cucurbite in a *balneum mariæ*; fit to it a head of tin, or of copper tinned, together with its refrigeratory; and lute on a receiver. Make the water in the bath boil, and keep up this degree of heat till nothing more will come over. When the diſtillation is finiſhed, you will find in the receiver a rectified Eſſential Oil, which will be clearer, thinner, and better ſcented than before it was thus re-diſtilled; and in the bottom of the cucurbite will be left a matter of a deeper colour, more tenacious, more reſinous, and of a leſs grateful ſmell.

OBSERVATIONS.

ESSENTIAL Oils, even the pureſt, the beſt prepared, and the thinneſt, ſuffer great changes, and are much impaired by growing old: they gradually turn thick and reſinous; their ſweet, grateful ſcent is loſt, and ſucceeded by a more diſagreeable ſmell, ſomewhat like that of Turpentine. The cauſe of theſe changes is that their fineſt and moſt volatile part, that which contains moſt of the odorous principle, is diſſipated and ſeparated from that which contains leaſt of it; which therefore grows thicker, and comes ſo much the nearer to the nature of a reſin, as the quantity of Acid, that was diſtributed through the whole Oil before the diſſipation of the more volatile part, is, after ſuch diſſipation, united and concentrated in the heavieſt part; the Acid in Oils being much leſs volatile than the odorous part, to which alone they owe their levity.

Hence it appears what precautions are to be uſed for preſerving Eſſential Oils as long as poſſible without ſpoiling. They muſt be kept in a bottle perfectly well ſtopped, and always in a cool place, becauſe heat quickly diſſipates the volatile parts. Some authors direct the bottle to be kept under water.

If theſe Oils ſhould grow thick and reſinous by age, yet they are not to be thrown away. We ſhall ſhew in the analyſis of Balſams and Reſins, that, from theſe thick and even ſolid ſubſtances, Eſſential Oils may be drawn, as thin and as limpid as from plants. Eſſential Oils thickened by time may, therefore, be treated like Balſams, and actually analyzed, by ſeparating all the ſubtile odorous matter they contain from their thick acid parts. For this purpoſe they need only be diſtilled with a degree of heat juſt ſufficient to elevate the thin odorous parts, without raiſing the thick matter.

The reſidue left at the bottom of the veſſel, becauſe it could not riſe in diſtillation, is much thicker and leſs odorous than the Oil was before rectification. The reaſon of this is evident, and follows from what hath juſt been ſaid. This remainder diſſolves in Spirit of Wine more readily, and in greater quantity, than the light Oil drawn from it; becauſe it contains more Acid, and becauſe Oils owe their ſolubility in this menſtruum to their Acid part, as is proved in our Memoir on Oils already quoted.

When we come to treat of Reſins we ſhall enquire more particularly what this remainder is, and what principles it yields when analyzed: in this place it is ſufficient to take notice that though all the Oil, of which it made a part, came over at firſt with the heat of boiling water, yet it cannot now be raiſed by the ſame degree of heat in diſtillation; becauſe it is not now combined with the principle of odour which gives the Oil its volatility, and becauſe it is rendered ſluggiſh by being clogged with too great a proportion of Acid.

From what hath been already ſaid it muſt be concluded, that Eſſential Oils ſuffer great diminution by being rectified; and that in proportion to the quantity of reſinous matter left behind. All this reſinous matter, while combined with a proper quantity of the odorous principle of the plant, (that is, at the time of its being diſtilled, and a little while after) was really an Eſſential Oil: the change of its nature therefore is entirely owing to its having loſt that principle.

An Eſſential Oil, though rectified, is ſtill as apt to change and be ſpoiled as before, becauſe it ſtill continues to loſe its odorous principle by degrees. After ſome time, therefore, it requires a ſecond rectification, which again leſſens its quantity. In ſhort, it is plain that Oils will, in a number of years, greater or ſmaller according to their nature, and the manner in which they are kept, be wholly changed, and metamorphoſed into a reſinous matter, from which no thin Oil can be drawn with the heat of boiling water: and this is a proof of the fugacity of the odorous principle, or *Spiritus Rector*, of plants, which, when united with their lighteſt Oil, gives it the character of an Eſſential Oil.

This reſinous matter to which Eſſential Oils are finally reduced, being ſubjected to repeated diſtillations with a degree of heat ſuperiour to that of boiling water, is ſtill capable of yielding a certain portion of a thin, limpid, ſweet-ſcented Oil, which is as light as an Eſſential Oil; as we obſerved before is the caſe with Fat Oils drawn by expreſſion; but the thin Oil obtained by this means, though it poſſeſſes almoſt all the properties of an Eſſential Oil, is not for all that a genuine one; ſeeing it hath not the ſame odour with the plant from which it was originally drawn.

Eſſential Oils muſt be rectified in the *balneum mariæ*, as ordered in the proceſs: for, as ſome of the Oil touches the ſides of the veſſel in the operation, if that veſſel be made hotter than boiling water, the thick matter will riſe with the thin Oil, which therefore will not be rectified.

Rectification is of uſe not only for procuring to Eſſential Oils the tenuity and levity they may have loſt by age, but alſo to ſeparate them from other oily matters with which they may be adulterated. If, for inſtance, an Eſſential Oil be not properly diſtilled; if, by the addition of too much Salt, the water have acquired a degree of heat greater than that of pure boiling water, and, in conſequence thereof, ſome of the heavy Oil of the plant hath riſen with the Eſſential Oil, and mixed therewith the Eſſential Oil may, by rectification, be ſeparated from this heterogeneous Oil; which, being heavier and incapable of riſing with the heat of pure boiling water, will remain at the bottom of the veſſel.

The effect will be the ſame, if your Eſſential Oil be falſified with a mixture of any Fat Oil, as is often the caſe: for, ſome of them being extremely dear, the vender frequently adds a portion of Fat Oil to encreaſe the quantity. For this purpoſe Oil of Ben is generally uſed.

When an Eſſential Oil is thus falſified with a mixture of any Fat Oil, it may be diſcovered by letting a few drops of it fall into rectified Spirit of Wine; which will diſſolve the Eſſential Oil only, leaving the Fat Oil quite untouched.

Eſſential Oils are ſometimes falſified by mixing them with a certain quantity of Spirit of Wine. This fraud doth not render their ſmell leſs fragrant: on the contrary, it becomes rather more agreeable and quicker. In order to try an Oil ſuſpected of being falſified in this manner, drop a little of it into very clear water. If a milky cloud appear in the water, be aſſured the Oil is mixed with Spirit of Wine: for as this liquor unites more readily with water than with Oil, it quits the Oil with which it was mixed to incorporate with the water: mean time a good deal of the Oil, that was diſſolved by the Spirit of Wine, and is now ſeparated from it by the intervention of water, neceſſarily remains diſperſed through this water in very ſmall particles; and theſe form the milky cloud produced on this occaſion.

An Eſſential Oil may alſo be adulterated with another Eſſential Oil that is much more common, and of much leſs value. Thoſe who practiſe this fraud generally employ Oil of Turpentine for that purpoſe, on account of its cheapneſs and tenuity. The cheat is eaſily diſcovered by moiſtening a linnen rag with the Oil ſuppoſed to be thus falſified, and then holding the rag a little before the fire, which preſently diſſipates the odorous part of the falſified Oil. This odour, which prevented our diſtinguiſhguiſhing that of the Oil of Turpentine, being vaniſhed, the peculiar ſmell of the Turpentine, which is much more permanent, remains alone; and is ſo perceptible that it cannot eaſily be miſtaken.

Thoſe, who are much accuſtomed to ſee and examine Eſſential Oils, have ſeldom occaſion to make the experiments here propoſed for diſcovering their qualities. A certain degree of thickneſs, partaking of unctuoſity, in an Eſſential Oil, convinces them that it is falſified with a Fat Oil: on the other hand a greater degree of tenuity, together with a quicker ſmell, than a pure Eſſential Oil ought to have, diſcovers the admixture of Spirit of Wine. Laſtly, any one, whoſe ſenſe of ſmelling is not very dull, will eaſily diſcover the odour of the Oil of Turpentine, though diſguiſed by that of the Eſſential Oil with which it is mixed.

PROCESS II.

To fire Oils by combining them with highly concentrated Acids: inſtanced in Oil of Turpentine.

MIX together in a glaſs equal parts of concentrated Oil of Vitriol, and highly ſmoking freſh-drawn Spirit of Nitre: pour this mixture at ſeveral times, but ſuddenly, on three parts of Oil of Turpentine, ſet for that purpoſe in a glaſs baſon. By a part here muſt be underſtood a dram at leaſt. A moſt violent commotion, accompanied with ſmoke, will immediately be raiſed in the liquors, and the whole will take fire in an inſtant, flame, and be conſumed.

OBSERVATIONS.

THERE is not in Chymiſtry a phenomenon more extraordinary, and more ſurpriſing, than the firing of

Oils by mixing them with Acids. It could never have been ſuſpected that a mixture of two cold liquors would produce a ſudden, violent, bright, and laſting flame, like that we are at preſent conſidering. Becher gave notice, in his *Phyſica Subterranea*, that highly rectified Spirit of Wine would be ſet on fire by mixing it with highly concentrated Oil of Vitriol.

Afterwards Borrichius, a Daniſh Chymiſt, publiſhed a proceſs for kindling Oil of Turpentine by mixing it with the Nitrous Acid, as we find in the Philoſophical Tranſactions of Copenhagen for the year 1671. Moſt Chymiſts have ſince tried to repeat thoſe experiments, and particularly to fire the Oil of Turpentine by mixing it with Oil of Vitriol, or Spirit of Nitre; but to no purpoſe, when they made uſe of the Oil of Vitriol, till Mr. Homberg told us, in the Memoirs of the Academy of Sciences for 1701, that he had fired Oil of Turpentine by mixing it with Oil of Vitriol.

To make the experiment ſucceed he requires "that the Oil of Vitriol be dephlegmated as much "as poſſible, and that the Oil of Turpentine be "the laſt that comes over in diſtillation, which is "thick like a ſyrop, and of a dark-brown colour; "for that which is white, and riſes at the beginning "of the diſtillation, never takes fire." Theſe are his own words: but no body elſe hath ever ſucceeded in making the experiment.

Tournefort had ſucceeded, a little before Homberg, in firing, not Oil of Turpentine indeed, in which he always failed, but the Oil of Saſſafras, by mixing it with an equal quantity of well dephlegmated Spirit of Nitre. Homberg came afterwards, as appears by the Memoirs of the Academy for the year 1702, to fire with Spirit of Nitre the Eſſential Oils of the aromatic plants of India; and in 1706 Mr. Rouviere fired, with Spirit of Nitre, the empyreumatic Oil of Guaiacum. While this Oil of Guaiacum is burning, a poros ſpungy body riſes from the midſt of the flame, to the height of about two foot above the veſſel.

Laſtly, ſeveral years after all theſe diſcoveries, Meſſrs. Geoffroy and Hoffman, the one at Paris, and the other at Hall in Saxony, found a way to fire the Æthereal Oil of Turpentine, each by a different proceſs; yet agreeing in this, that they both combined the Vitriolic Acid with the Nitrous, and with this compound Acid fired that Æthereal Eſſential Oil, which is one of the thinneſt, and, probably for that very reaſon, the moſt unfit to produce a flame with Acids.

The moſt celebrated Chymiſts, as appears from this ſhort account, have employed themſelves in firing Eſſential Oils; but no body attempted the experiment on Fat Oils. It was not ſo much as ſuſpected that they were capable of taking fire after this manner, till in 1745 I read before the Academy a Memoir on Oils, which I have already mentioned, and in which I expreſs myſelf thus:

" I put two ounces and a half of Walnut Oil " into the bottom part of a broken retort, having " the figure of a cap, or concave hemiſphere; and " poured thereon two ounces of ſmoking Spirit of " Nitre. It was ſcarce put in when a conſiderable " ebullition aroſe, with a very thick ſmoke. As I " found it continually increaſing, and very faſt " too, I retired a little that I might obſerve the " event without danger. This caution was not " unneceſſary: for immediately the whole mixture " blew up as high as the cieling, with a noiſe like " the diſcharge of a muſket. Nothing was left " in the veſſel but a black matter, which ſtill con- " tinued to boil a little and run over, and at laſt " remained very rare, ſpungy, and as full of holes " as a ſieve: its conſiſtence alſo was ſuch that it

" did not ſtick to my fingers when I handled " it.

" As Mr. Geoffroy, who firſt found the means " of firing the natural *Balſams*, obſerved in them " a ſimilar exploſion on that occaſion, it appears " that my Oil was very near taking fire in this ex" periment: which makes me preſume that we may " at laſt ſucceed in firing Fat Oils likewiſe, and " conſequently all others; ſeeing theſe have al" ways been looked upon as the moſt unlikely to " produce that phenomenon. I imagine that, to " accompliſh this, nothing more is neceſſary than " to make uſe of ſufficiently great quantities, and " to order it ſo that the ſurfaces of the liquors " where they come into contact may be of a large " extent."

Afterwards, in 1747, Mr. Rouelle read before the Academy a Memoir on the accenſion of Oils by Acids. That Memoir contains a great number of curious experiments, and peculiar manual operations deſcribed very diſtinctly, from which there reſults a general method of firing without fail, not only Eſſential Oils, but even any Fat Oil whatever: ſo that my conjecture concerning the poſſibility of firing theſe latter Oils, mentioned in my above-cited Memoir of 1745, is now changed into a certainty. I ſhall proceed to explain how I conceive theſe accenſions are brought about, and endeavour to account for the phenomenon from ſuch cauſes as to me ſeem the moſt probable.

A due attention to the phenomena produced by mixing Oils with Acids will enable us, I imagine, to diſcover the natural cauſe why the Oils take fire. It is certain, and demonſtrated by the moſt deciſive experiments, that the friction of ſeveral bodies rubbing againſt each other produces heat; and that when thoſe bodies are combuſtible, and the heat produced by their friction riſes to a certain degree, they take fire. This, in my opinion, is what happens to Oils when mixed with concentrated Acids. When theſe two ſorts of ſubſtances ruſh into union with rapidity, as in the experiments under conſideration, there muſt neceſſarily be a great friction among their parts. This friction produces the heat obſerved at the time of their union. The more concentrated the Acids are, with the greater violence and rapidity do they act upon the Oils, and the greater is the heat raiſed. If the Acids be concentrated to ſuch a degree as to produce, by uniting with the Oils, a heat equal to that of an ignited body, the combuſtible ſubſtances that are expoſed to it, which in this caſe are Oils, muſt needs take fire and flame.

The heat produced on this occaſion is ſo great, that, even when the inflammation doth not take place, if you touch the ſurface of the Oil with your finger, as ſoon as the Acid hath had its effect, you will find it burn you like a live coal.

Two pieces of wood, rapidly and violently rubbed againſt each other, take fire. What is it that is kindled in this caſe? It can be nothing but their Oil: for they contain no other combuſtible principle. Why doth this Oil take fire? I do not think it poſſible to aſſign any reaſon for it, but the heat produced by the friction of the pieces of wood containing the Oil. If, when Oil is diſperſed in a body, of which it is only one component principle, and conſequently mixed with many ſaline, aqueous, and earthy parts, that are not inflammable, but, on the contrary, make the Oil leſs ſo, the Oil nevertheleſs takes fire, and burns when agitated by a ſufficient degree of heat; why ſhall not this very Oil, when ſeparated from the mixt of which it made a part, when united into one diſtinct maſs, and entirely, or almoſt entirely, freed from the heterogeneous, incombuſtible parts with which it was combined,

bined, and conſequently now more inflammable than before; why, I ſay, ſhall it not take fire, when expoſed to a degree of heat equal, or rather ſuperiour, to that which is produced by rubbing two pieces of wood together?

Let us now examine the phenomena produced when Oils are fired by Acids, all the circumſtances that favour or hinder their accenſion, and ſee if they agree with the explanation here offered.

Firſt, no ſort of Oil will take fire with any Acid whatever that is not highly concentrated; for weak Acids act but feebly on Oils, and diſſolve them ſlowly; ſo that the friction is neither quick nor violent, and conſequently produces too faint a heat, far below the degree of ignition.

Secondly, no inflammation is produced when Acids and Oils are mixed in too ſmall quantities; but the more Acid and Oil you mix together, the greater is the certainty of ſucceeding: for the heat is exactly in proportion to the friction that produces it; and the total quantity, or amount, of this friction is ſo much the greater, as there are more particles rubbing againſt each other at the ſame time. So that if a very ſmall quantity of Acid and Oil be mixed together, there will be but a very ſmall quantity of friction, and conſequently a very ſmall quantity of heat; and in that caſe no inflammation. It was with a view to avoid theſe inconveniences, and to procure the oppoſite advantages, in as great a degree as poſſible, that, in the paſſage above quoted from my Memoir of Oils, I propoſed mixing together large doſes of Acid and of Oil, as one of the means by which we might ſucceed in the accenſion of Fat Oils.

Thirdly, the figure of the veſſel in which the two liquors are mixed together is not a matter of indifference. A wide-ſpreading veſſel, of a large diameter with reſpect to the quantity of liquor it is to contain, favours the inflammation much more than one of a ſmall diameter. Nay, it may not ſucceed at all in too narrow a veſſel, though all other circumſtances be properly attended to.

The reaſon of this is, that the activity of heat produced by friction is not in proportion to the ſucceſſive, but to the ſimultaneous frictions: for the heat actually produced by the frictions of an hundred particles, rubbing ſucceſſively againſt each other, with intervals ſufficient to let the heat go off almoſt as faſt as it is generated, would be equal to the friction of a ſingle particle only; whereas the heat actually produced by the friction of the ſame number of particles, all rubbing againſt each other at the ſame inſtant, would be equal to the frictions of all the particles taken together, and conſequently an hundred times more active than the other *. This being laid down, it is eaſy to conceive how a large veſſel favours the accenſion more than a ſmall one. It is certain that two liquors which mutually preſent large ſurfaces to each other, at the inſtant of their being mixed together, touch each other at one and the ſame time in a much greater number of points, than if each had but a ſmall ſurface; and conſequently that they muſt unite much ſooner, and with greater rapidity, in the former caſe than in the latter.

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* I believe this propoſition is not ſtrictly true: for it appears to me, that, in order to make the heat, produced by the ſimultaneous frictions of an hundred particles, an hundred times more active than that produced by the ſucceſſive frictions of the ſame number of particles, it is neceſſary that the ſimultaneous frictions ſhould act all together in one point or center; which is impoſſible. But, as the particles that rub againſt each other, in the preſent caſe, are very near and contiguous, it is ſtill true that the heat, reſulting from their ſimultaneous frictions, is much more active than that produced by ſucceſſive frictions only: which is ſufficient for our preſent purpoſe.

With theſe views, and in order to give the liquors this advantageous diſpoſition, I recommended it as what would greatly promote the inflammation of Fat Oils, to order the liquors ſo, that, at the moment of their mixture, a large ſurface of each might come into contact with the other.

Fourthly, if we reflect on the experiments hitherto made for kindling Oils by Acids, we ſhall eaſily be convinced that all Oils are not equally apt to be fired; and that light, æthereal, very thin, Eſſential Oils do not produce this phenomenon ſo readily and ſo ſurely, as thoſe of the ſame kind that are heavy and thick, or at leaſt ſoon grow thick upon being mixed witn Acids.

Mr. Homberg ſays poſitively in the above-cited paſſage of his Memoir, that he never could ſucceed in ſetting fire with the Acid of Vitriol to the white, æthereal Oil of Turpentine; that is, to the lighteſt which comes over firſt in diſtillation; but that the very ſame Acid ſet fire to "that which comes over "laſt in diſtillation, which is thick like a ſyrop, "and of a dark-brown colour."

All the experiments by which Oils have been fired, from thoſe of Becher and Borrichius, down to thoſe of Geoffroy and Hoffman, were made on the Eſſential Oils of the aromatic plants of India, which are the heavieſt we know, and on the empyreumatic Oil of Guaiacum, which, beſides being very ponderous, is alſo very thick.

Now theſe ſingular effects likewiſe agree perfectly well with our explanation. It is certain that the parts of a heavy fluid do not yield to any impulſe or ſhock, ſo eaſily as thoſe of a lighter fluid; juſt as the parts of a thick, viſcous fluid undoubtedly reſiſt any attempt to ſeparate them, ſo much the more the nearer the conſiſtence of that fluid is to ſolidity, or the further it is removed from the ſtate of fluidity. Now, the more reſiſtence the

Acid meets with in ſeparating and dividing the parts of the Oil, as it muſt do to diſſolve them, the more conſiderable will be the force and motion with which it muſt neceſſarily act to ſurmount thoſe obſtacles; beſides, as experience teaches us that the denſity and viſcidity of the Cils do not, at leaſt to ſenſe, diminiſh the quickneſs and activity which the Acid exerts in uniting with them; the greater therefore muſt be the colliſions, frictions, and heat produced: and this plainly ſhews why heavy, thick Oils take fire, in this caſe, more readily than thoſe which are fluid and light.

It may here be objected that Fat Oils, which are thicker and heavier than the light Eſſential Oils, take fire nevertheleſs with greater difficulty. This objection is eaſily anſwered, by obſerving that when we ſay Acids fire heavy thick Oils with more eaſe than thin light Oils, this poſition muſt be reſtricted to Oils of the ſame kind, on which Acids have an equal, or nearly equal, action; that is, to ſuch Oils as differ from each other in no other reſpect but their thickneſs and weight.

For example, Mr. Homberg, who could by no means ſet fire, with Oil of Vitriol, to the Oil that riſes firſt in the diſtillation of Turpentine, found that the ſame Acid would fire the Oil that comes laſt over: and therefore it is reaſonable to attribute his ſucceſs, in firing this laſt Oil, to its being thicker and heavier than the former; ſeeing theſe two Oils are in other reſpects of the ſame nature; that Acids have an equal action on both; and that they differ from each other only in the qualities ſpecified above.

But it is evident, that, if the Oils compared together be of different kinds, and differ from each other, not only in weight and thickneſs, but alſo by containing different principles, or, at leaſt, the ſame principles combined differently, and in different proportions, the action of any Acid on thoſe Oils muſt alſo be different; and that regard muſt be had thereto in determining their degrees of inflammability.

Now all this is applicable to Fat Oils, when compared with light Eſſential Oils, in point of inflammability. If all theſe Oils were of the ſame nature, and differed from each other in weight and thickneſs only, the objection drawn from Fat Oils, which though thicker than Eſſential Oils do not take fire ſo eaſily, would be a very good one, and fact would be againſt our reaſoning. But this is far from being the caſe: the properties, as well as the analyſis, of Fat Oils ſhew their nature to be very different from that of Eſſential Oils; that there is more water in their compoſition; and that they are full of a mucilaginous or gummy principle, which muſt greatly obſtruct their inflammability, and the action of Acids upon them.

None of the effects therefore that attend the firing of Oils with Acids is repugnant to our way of accounting for the phenomenon, which is one of the moſt beautiful in all Natural Philoſophy. To conclude this important ſubject, nothing now remains but to conſider the effects produced by the Vitriolic Acid in theſe accenſions.

This Acid, though of a ſtronger nature, and capable of being more highly concentrated than the Nitrous Acid, ſeems however leſs qualified to produce a flame with Oils. Indeed Mr. Homberg fired Oil of Turpentine by mixing it with Oil of Vitriol: but I do not know that the experiment hath ſucceeded with any other Chymiſt; on the contrary, moſt of thoſe who have tried it affirm that they never could fire any Oil with that Acid alone.

Oils are probably in the ſame caſe as metallic ſubſtances, with regard to theſe two Acids. We know that the Nitrous Acid diſſolves thoſe ſubſtances with vaſtly more activity and violence than the Vitriolic Acid exerts upon them; which may depend either on the diſpoſition and configuration of their parts, or on the portion of phlogiſton which, according to the opinion of moſt Chymiſts, is united with the Nitrous Acid, is its peculiar characteriſtic, and the cauſe of the great vivacity with which it diſſolves almoſt all matters that contain the phlogiſton.

I ſay *almoſt* all matters that contain the phlogiſton; becauſe there are ſome ſubſtances that contain a great deal thereof, and yet are not at all acted on by the pure Nitrous Acid. Theſe ſubſtances are matters perfectly charred; that is, ſuch as are capable of enduring the greateſt violence of fire in cloſe veſſels, without yielding a ſingle atom of Oil; that burn almoſt quite away, yet only grow red-hot without flaming; or at leaſt produce but a very ſmall, ſlight flame, from which it is impoſſible to obtain the leaſt particle of ſoot or fuliginoſity; in a word, that contain an inflammable matter, but ſuch as is fit to be an ingredient in the compoſition of metallic ſubſtances, to which the peculiar title of the Phlogiſton is appropriated.

I ſay then that, if the Nitrous Acid be poured on a mere coal, perfectly charred, it is impoſſible for the Acid, be it ever ſo highly concentrated, to ſet the coal on fire, though heated before to the greateſt degree that it can poſſibly admit of without kindling; and, which is ſtill more remarkable, if a live coal be plunged into the moſt highly ſmoking Spirit of Nitre, it will be extinguiſhed as if dipt in pure water.

But to return to the Vitriolic Acid: it is ſingular enough that this Acid, which attacks Oils with leſs activity, and for that reaſon ſeems leſs fit to ſet them on fire, than the Nitrous Acid, yet greatly promotes their accenſion, when mixed with that very

Acid. This may be owing to its rendering the Oils with which it mixes heavier and thicker; or elſe, as Mr. Rouelle conjectures with great probability, being more concentrated than the Nitrous Acid, and having a greater affinity with water, it dephlegmates the other, and thereby increaſes its activity; or laſtly, this may ariſe from ſome other cauſe yet unknown to us, and perhaps from that by which the Acids of Nitre and of Sea-ſalt, which, when ſeparate and perfectly pure, can neither of them diſſolve Gold, are enabled, when combined together, to make a perfect ſolution of that metal.

PROCESS III.

To combine Eſſential Oils with Mineral Sulphur. Balſam of Sulphur. This compoſition decompounded.

PUT into a matraſs one part of Flowers of Sulphur; pour on them ſix parts of the Eſſential Oil of Turpentine, for inſtance; ſet the matraſs in a ſand-bath, and heat it gradually till the Oil boil. The Sulphur, which at firſt lay at the bottom of the matraſs, will begin to melt, and appear to diſſolve in the Oil. When it hath boiled in this manner for about an hour, take the matraſs from the fire, and let the liquor cool. A great deal of the Sulphur that was diſſolved therein will ſeparate from it as it cools, and fall to the bottom of the veſſel in the form of needles, much like a Salt ſhooting in water.

When the liquor is perfectly cold, decant it from the Sulphur that lies at the bottom of the veſſel: to that Sulphur put freſh Oil of Turpentine, and proceed as before: the Sulphur will again diſappear, and be diſſolved in the Oil; but when the mixture is cold you will find new cryſtals of Sulphur depoſited at the bottom. Decant once more this Oil from the cryſtals, and pour on freſh Oil to diſſolve them: continue the ſame method, and you will find that about ſixteen parts of Eſſential Oil are required to keep one part of Sulphur diſſolved when cold. This combination is called *Balſamum Sulphuris Terebinthinatum*, if made with Oil of Turpentine; *Aniſatum* if with Oil of Aniſe-ſeeds; and ſo of others.

OBSERVATIONS.

ESSENTIAL Oils do not diſſolve Sulphur, in ſuch quantities, and with ſo much eaſe, as Fat Oils do. It was ſhewn above that a Fat Oil is capable of keeping a conſiderable quantity of Sulphur in ſolution; whereas no leſs than ſixteen parts of Eſſential Oil are required to diſſolve one part only of Sulphur, as in this proceſs.

The property which Sulphur hath of ſeparating, in part, from the Eſſential Oil in which it is diſſolved, and falling to the bottom of the veſſel in the form of cryſtals, as the Oil cools, proves that it is a kind of Neutral Salt, which, being inſoluble in water becauſe of the great quantity of inflammable matter that ſerves it for a baſis, is not to be diſſolved but by ſubſtances that actually contain themſelves a great deal of inflammable matter; ſuch as Oils and Metallic ſubſtances.

Though the latter are almoſt always ſolid, it nevertheleſs unites with ſeveral of them into regular forms, reſembling ſaline cryſtals in every thing but pellucidity; as appears, for example, in ſeveral Pyrites, Antimony, and ſome other ſulphureous Minerals. But when it is diſſolved in Oils, eſpecially in ſuch as are capable of keeping but a ſmall quantity thereof in ſolution, and conſequently drop a good deal of it as they cool, it is preciſely in the caſe of one of thoſe Salts whereof hot water diſſolves more than cold; that is, the Oil, that is ſaturated with as much Sulphur as it can poſſibly take up when boiling hot, lets ſome part thereof precipitate as it cools; while the Sulphur thus ſeparated from the Oil unites into little glebes of a regular figure, and actually cryſtallizes; in the ſame manner as Nitre, when boiling water hath diſſolved as much thereof as it can poſſibly take up, partly ſeparates from it when it cools, and falls to the bottom of the veſſel in ſmall cryſtalline *moleculæ*, of the form peculiar to that Salt.

M. Homberg made ſome very curious experiments on this combination of Sulphur with an Eſſential Oil. In the Memoirs of the Academy he gives the following analyſis thereof.

" Put your Sulphur diſſolved by Oil of Turpen- " tine into a pretty large retort, becauſe the matter " puffs up towards the end, and diſtill with a very " gentle heat for twelve or fifteen days and nights. " There will come over about two thirds of the " quantity of a colourleſs Oil of Turpentine, and at " the ſame time *a pretty conſiderable quantity* of a " whitiſh ponderous water, as acid as good Spirit " of Vitriol. After this the drops of Oil that " come off will begin to be red. Then change " your receiver, and increaſe the fire gradually; " and in ſeven or eight hours time, with a very " great heat, force off all that will riſe, uſing a " glaſs retort for your recipient. At laſt, moſt of " the Oil will come over into the receiver very " thick and high-coloured, ſtill accompanied with " a whitiſh and very acid water. In the retort will " be left a black *caput mortuum*, ſpungy or foliated, " ſhining and inſipid. . . . . This *caput mortuum* " neither grows white, nor flames, nor waſtes con- " ſiderably in a ſtrong fire.

" The matter that comes over into the receiver " muſt be diſtilled again, with a very gentle heat " continued for ſeveral days and nights, in order "to ſeparate once more the colourleſs Oil and the "remaining acid water, till the Oil begin to come "off red. Then take the retort from the fire, and "on the black gummy matter left in it pour good "Spirit of Wine; mix the whole well together, "and diſtill with a very gentle heat. When this "Spirit of Wine is come off, pour ſome freſh on "the black gum left in the retort, and diſtill as "before. Repeat this till the Spirit of Wine ceaſe "to have a bad ſmell."

There is great reaſon to believe, that, by the union which the Sulphur contracts with the Oil, the coheſion of the Acid and the Phlogiſton, which conſtitute that mineral, is conſiderably weakened; and that this is what occaſions the decompoſition of the Sulphur ſo manifeſt in M. Homberg's analyſis. The inflammable matter of the Sulphur is ſo incorporated with that of the Oil in the ſolution, that they form together one homogeneous whole; by which means the Acid of the Sulphur, which is of courſe diſperſed through the whole liquor, is not now combined with the Phlogiſton, as it was in the Sulphur before it was blended with the Oil; that is, with the pure Phlogiſton; but with that Phlogiſton which conſtitutes the oily mixture, or, which is the ſame thing, with actual Oil. And this is the reaſon that a compoſition of Oil and Sulphur yields, in diſtillation, nearly the ſame principles that a combination of the ſame Oil with the Vitriolic Acid would yield.

We have already ſeen, under the head of Fat Oils, that when Oils are combined with Acids, if this combination be again decompounded by diſtillation, thoſe two ſubſtances cannot be obtained in their original ſtate; but that they are changed and partly decompoſed. The caſe is the ſame in the experiment before us. We firſt get, by diſtillation, a pretty conſiderable quantity of Oil of Turpentine, that ſeems to have ſuffered no change at all. This firſt Oil is that which the action of fire ſeparates from the Acid; and this it effects with ſo much the more eaſe that, a great quantity thereof having been neceſſarily uſed to diſſolve a little Sulphur, it greatly exceeds the quantity of Acid in the mixture, and that the diſtillation is ordered to be made with a very weak degree of heat: for M. Homberg ſays it ought to be continued twelve or fifteen days and nights. Now this manner of diſtilling, with a very gentle heat, is the moſt effectual means of ſeparating Oils, eſpecially light Eſſential Oils, from Acids; becauſe theſe Oils riſe in diſtillation with very little heat; whereas the Acids, being much more ponderous, require a great deal more.

The Oil that riſes firſt in diſtillation appears indeed to be the ſame with that which was originally uſed in the mixture; but the quantity is much ſmaller: firſt, becauſe ſome part of it, being combined with the Acid of the Sulphur, is thereby rendered thick and heavy, which hinders it from riſing in this firſt diſtillation with a very gentle heat, and is the reaſon that it cannot be elevated without a much ſtronger degree of fire. It is this part that afterwards come over in the form of a red liquor upon encreaſing the fire.

The ſecond cauſe why the quantity of Oil is leſſened is, that part of it is decompoſed in the operation. This decompoſed part of the Oil furniſhes that conſiderable quantity of water which aſcends at the ſame time with the Oil, or a little after it, and ſerves for a vehicle to the Acid that riſes with it in this firſt diſtillation; which Acid, though pretty ſtrong, is now much more loaded with water than when it was an ingredient in the combination of Sulphur. This acid water is of a milky white colour, becauſe many Oily particles are ſuſpended and diffuſed in it, but not perfectly diſſolved.

The *caput mortuum* that is left in the retort, after all the red thick Oil is driven up by a very ſtrong degree of fire, is a ſort of charred matter, conſiſting of ſome of the earth of the Sulphur, and of the decompoſed Oil, united with a Phlogiſton, which is probably furniſhed by both theſe ſubſtances. This matter contains alſo a little Acid fixed with it. This Acid re-produces Sulphur, or at leaſt becomes ſulphureous, and flies off in vapours, when the coal is urged by a violent forge-heat: for Mr. Homberg obſerved that by this means it exhaled an odour of Sulphur, and loſt in weight.

This charred matter is of a ſingular nature: for, by being expoſed to a forge-heat, and even to the heat in the focus of a burning-glaſs, it ſeemed to ſuffer no other change than ſome loſs of weight, occaſioned by the evaporation of the acid effluvia carried off by the heat; for it ſtill retained its black colour, and was neither conſumed nor vitrified. In order to melt it, Mr. Homberg was forced to mix it with Borax. This Salt converted it into a glaſs of a dark-grey colour: and, as there appeared a little verdegris on the ſurface of this glaſs after keeping it in a moiſt place, he thereby found that the Sulphur he had uſed contained a little Copper.

We know that the earth of Copper is refractory, and that it communicates a dark colour to matters vitrified along with it: and perhaps it was the cauſe why the fixed matter in queſtion retained its blackiſh colour ſo obſtinately, notwithſtanding the phlogiſton that muſt have been in it at firſt was, in all probability, conſumed by the violent ignitions it underwent.

As to the thick oily matter, called *gummy* by Mr. Homberg, from which he directs Spirit of Wine to be repeatedly diſtilled, till it ceaſe to have a diſagreeable ſmell, there is great reaſon for thinking it to be, as we ſaid before, a portion of the

Oil which the Acid hath rendered thick and heavy. The Spirit of Wine diſſolves and carries up the moſt acid part, which always hath a diſagreable ſmell.

Mr. Homberg ſays that "the part remaining "after this, which he calls the *Gum of common Sulphur*, hath a pleaſant balſamic odour; that it "partly diſſolves in Spirit of Wine, a hard reſinous "matter being left, which will not diſſolve, either "in Spirit of Wine, or in the ſtrongeſt lixivium." Of conſequence therefore it is neither a reſinous matter, nor a ſulphur; "yet it diſſolves perfectly in "diſtilled Oils." What then is this ſingular body? It is certainly a ſubject for very curious enquiries. In general, Mr. Homberg's whole proceſs is full of intereſting facts, and well deſerves to be repeated, carried further, and carefully attended to.

PROCESS IV.

To combine Eſſential Oils with Fixed Alkalis. Starkey's Soap.

TAKE Salt of Tartar, or any other Alkali, thoroughly calcined. Heat it in a crucible till it be red, and in that condition throw it into a hot iron mortar: rub it quickly with a very hot iron peſtle; and as ſoon as it is powdered pour on it, little by little, nearly an equal quantity of Oil of Turpentine. The Oil will enter into the Salt, and unite intimately with it, ſo as to form a hard paſte. Continue rubbing this compoſition with the peſtle, in order to complete the union of the two ſubſtances; and, as your Oil of Turpentine diſappears, add more, which will unite in the ſame manner, and give a ſofter conſiſtence to the ſoapy maſs. You may add ſtill more Oil, according to the conſiſtence you intend to give your Soap.

OBSERVATIONS.

ESSENTIAL Oils do not unite near ſo eaſily as Fat Oils with Alkalis. For this reaſon, to make a Soap with an Eſſential Oil, we muſt take a method different from that uſed in common ſoaperies. For if an Eſſential Oil be ſubſtituted for the Fat Oil, in the ordinary way of making Soap, far from combining with the alkaline lixivium, though ever ſo ſtrong, it will be wholly diſſipated and vaniſh: ſo that, after boiling ſome time, there will be nothing to be found but the lye juſt as when firſt put in, only a little more concentrated.

The water, in which the Alkali is diſſolved when in the form of a lye, is the principal thing that hinders the Salt from uniting with the Eſſential Oil. Water is ſuch an enemy to this union, that, if the Alkali be ever ſo little moiſt, the operation will not ſucceed; even though all the other precautions mentioned in the proceſs ſhould be exactly obſerved.

In order therefore to free the Alkali from all humidity, it is neceſſary to begin with making it red-hot; and then, that this Salt, which is very greedy of moiſture, may not imbibe any from the air before it be mixed with the Eſſential Oil, it muſt not be ſuffered to cool; but the mixture muſt be made in a hot veſſel, as ſoon as the Salt is reduced to powder. When every particle of the Salt is once covered with Oil, you need not fear its attracting any moiſture, at leaſt very quickly, becauſe the Oil oppoſes its admiſſion.

Starkey, the firſt Chymiſt who found the means of making Soap with an Eſſential Oil, and by whoſe name this kind of Soap is therefore called, made uſe of a much more tedious method than that propoſed in our proceſs. He began with mixing a very ſmall quantity of Oil with his Salt, and waited till all the Oil united therewith of its own accord, ſo as to diſappear entirely, before he added any more; and thus protracted his operation exceedingly, though in the main it was the ſame with ours. The method here propoſed is more expeditious, and was invented by Dr. Geoffroy.

Starkey's Soap diſſolves in water much as common Soap does, without any ſeparation of the Oil: and by this mark it is known to be well made. It may alſo be decompounded, either by diſtillation or by mixing it with an Acid: and its decompoſition, in either of theſe ways, is attended with nearly the ſame phenomena as the decompoſition of common Soap.

CHAP. VI.

OF THE SUBSTANCES OBTAINED FROM VEGETABLES BY MEANS OF A GRADUATED HEAT, FROM THAT OF BOILING WATER, TO THE STRONGEST THAT CAN BE APPLIED TO THEM IN CLOSE VESSELS.

PROCESS I.

To analyze Vegetable Subſtances that yield neither a Fat nor an Eſſential Oil. Inſtanced in Guaiacum-Wood.

TAKE thin ſhavings of Guaiacum-Wood, and put them into a glaſs or ſtone retort, leaving one half thereof empty. Set your retort in a reverberating furnace, and lute on a large glaſs receiver having a ſmall hole drilled in it; ſuch as is uſed for diſtilling the Mineral Acids. Put a live coal or two in the furnace, to warm the veſſels gently and ſlowly.

With a degree of heat below that of boiling water, you will ſee drops of a clear inſipid phlegm fall into the receiver. If you raiſe the fire a little, this water will come ſlightly acid, and begin to have a pungent ſmell. With a degree of fire ſomewhat ſtronger, a water will continue to riſe which will be ſtill more acid, ſmell ſtronger, and become yellowiſh. When the heat comes to exceed that of boiling water, the phlegm that riſes will be very acid, high coloured, have a ſtrong pungent ſmell, like that of matters long ſmoked with wood in a chimney, and will be accompanied with a red, light Oil, that will float on the liquor in the receiver.

And now it is neceſſary that the operation be carried on very cautiouſly, and vent frequently given to the rarefied air by opening the ſmall hole in the receiver; ſuch an incredible quantity thereof ruſhing out of the Wood, with this degree of heat, as may burſt the veſſels to pieces, if not diſcharged from time to time.

When this red, light Oil is come over, and the air ceaſes to ruſh out with impetuoſity, raiſe your fire gradually, till the retort begin to redden. The receiver will be filled with denſe vapours; and together with the watery liquor, which will then be extremely acid, there will riſe a black, thick, ponderous Oil, which will fall to the bottom of the receiver, and ly under the liquor.

Then give the utmoſt degree of heat; that is, the greateſt your furnace will allow, and your veſſels bear. With this exceſſive heat a little more Oil will riſe, which will be very ponderous, as thick and black as pitch; and the veſſels will continue full of vapours that will not condenſe.

At laſt, when you have kept the retort exceeding red for a long time in this extremity of heat, ſo that it begins to melt if it be of glaſs, and you perceive nothing more come over, let the fire go out and the veſſel cool. Then take off your receiver: from the black Oil at bottom decant the acid liquor with the red Oil floating on it, and pour them both into a glaſs funnel, lined with brown filtering paper, and placed over a bottle. The acid liquor will paſs through the filter into the bottle, and the Oil will be left behind, which muſt be kept by itſelf in a ſeparate bottle. Laſtly, into another funnel, prepared as the former, pour the thick Oil remaining with a little of the acid liquor at the bottom of the receiver. This liquor will filter off in the ſame manner, and thus be ſeparated from the heavy Oil.

In the retort you will find your Guaiacum-ſhavings, not in the leaſt altered as to their figure, but light, friable, very black, ſcentleſs and taſteleſs, eaſily taking fire, and conſuming without flame or ſmoke: in ſhort you will find them charred to a perfect coal.

OBSERVATIONS.

HITHERTO we have examined the ſubſtances that may be obtained from vegetables, either without the help of fire, or with a degree of heat not exceeding that of boiling water. The analyſis of plants can be carried no further without a greater degree of heat: for, when the principle of odour and the eſſential oil of an aromatic plant are wholly extracted by the preceding proceſſes, if the diſtillation be afterward continued without increaſing the heat, nothing more will be obtained but a little Acid; which will ſoon ceaſe, as a ſmall part only of the quantity contained in the plant will be elevated; the reſt being either too ponderous, or too much entangled with the other principles of the body, to riſe with ſo ſmall a degree of heat.

In order therefore to carry on the decompoſition of a plant, from which you have, by the methods before

fore propoſed, extracted all the prnciples it is capable of yielding when ſo treated; or, which comes to the ſame thing, in order to analyze a vegetable matter, which affords neither an expreſſed nor an eſſential oil, it muſt be diſtilled in a retort with a naked fire, as directed in the proceſs, and be made to undergo all the degrees of heat ſucceſſively, from that of boiling water to the higheſt that can be raiſed in a reverberating furnace.

A heat inferiour to that of boiling water, with which we muſt begin in order to warm the veſſel gradually, brings nothing over, as hath been ſaid, but an inſipid water, deſtitute of all Acidity. By increaſing it nearly to the degree of boiling water, the diſtilled water comes to be ſlightly acid.

When the heat is made a little ſtronger than that which is neceſſary for the elevation of an Eſſential Oil, the Acidity of the water that comes off is much more conſiderable. It hath now both colour and ſmell, and there riſes with it a red, light Oil, that floats on the liquor in the receiver. This is not an Eſſential Oil; it hath none of the odour of the plant. Though ſo light as to float on water, yet it will not riſe with the degree of heat that raiſes Eſſential Oils, even thoſe that much ſurpaſs it in gravity, and will not ſwim on water as they do. This proves that the eaſe or difficulty, with which a particular degree of heat raiſes any ſubſtance in diſtillation, doth not depend altogether on its gravity: its dilatability, or the volatile nature of the matters with which it is ſo cloſely united as not to be ſeparated from them by diſtillation, may probably contribute greatly to produce this effect.

It is very ſurpriſing that a ſubſtance ſo hard, ſo compact, ſo dry, in appearance, as Guaiacum-wood, ſhould yield ſuch a large quantity of water by diſtillation; and it is equally ſo that it ſhould diſcharge ſo much air, and with ſo much impetuoſity, as nothing

thing but experience could render credible. We have, in the proceſs, directed the precautions to be taken when this air, from being prodigiouſly condenſed in the body of which it made a part, is ſet at large, ruſhes out of confinement, and expands with all its natural elaſticity. From this air ariſes the greateſt danger attending the operation.

It hath been remarked that the heavieſt and moſt compact woods yield the moſt air in diſtillation: and accordingly Guaiacum-wood, which we have choſen for an inſtance, as exceeding almoſt all others in hardneſs and weight, diſcharges a vaſt quantity of air when analyzed.

The thick, burnt, empyreumatic Oil, that comes over laſt in this diſtillation, is heavier than water; on account, probably, of the great quantity of Acid with which it is replete. The two kinds of Oil obtained in this analyſis may be rectified, by diſtilling them a ſecond time, or rather ſeveral times; by which means they will become lighter and more fluid, as we have ſeen happen to Fat and Eſſential Oils. In general, all thick, heavy Oils conſtantly owe theſe qualities to an Acid united with them; and it is by being freed from ſome of that Acid in diſtillation, that they always acquire a greater degree of lightneſs and fluidity from that operation. To theſe laws all vegetable Oils are ſubject, of what nature ſoever they be.

The analyſis of a vegetable ſubſtance, exhibited above, ſhews what may be obtained from them, when diſtilled in cloſe veſſels, with a graduated heat, from that of boiling water, to that which converts the mixt to a perfect coal; viz. Phlegm, an Acid, a light Oil, much Air, and a thick Oil. But this analyſis is far from being a complete one: it may be carried much farther, and made more perfect.

None of the principles obtained by this analyſis are pure, ſimple, and thoroughly ſeparated from the reſt. They are ſtill in ſome meaſure blended all together: their ſeparation is but begun; and each requires a ſecond and more accurate analyſis, to reduce it to the greateſt degree of purity of which it is capable. The Oil and the Acid chiefly merit ſo much pains.

A great deal of the Acid of the plant remains, as was ſaid, combined with the two ſorts of Oil here obtained; which we have reaſon to think differ no otherwiſe from one another, than as there is more or leſs Acid united with each. The beſt way of freeing theſe Oils from their redundant Acid is to diſtill them frequently from Alkalis and Abſorbents. Some of our beſt Chymiſts have taken this pains with ſeveral ſorts of Oils; but the method might be ſtill extended, and the operation carried further than hath yet been done.

The Acid is in the ſame circumſtances nearly as the Oil. The firſt that riſes is mortified with much water, to which it owes a good deal of its volatility. That which comes over laſt is much more concentrated, and conſequently heavier; yet it is ſtill very aqueous. It might be freed in a great meaſure from this adventitious water, and ſo rendered much ſtronger; which would give us a better opportunity to diſcover its nature and properties, of which we know but very little.

Water is not the only heterogeneous ſubſtance that diſguiſes the vegetable Acid: a pretty conſiderable quantity of the Oil of the plant is alſo combined with it, and contaminates its purity. The proof of this is, that, when theſe Acids are kept, in the ſame condition in which they firſt come over, for any length of time, in a glaſs veſſel, they gradually depoſite, on the bottom and ſides of the veſſel, an oily incruſtation, which grows thicker and thicker the longer it ſtands; and, as this oily matter ſeparates from it, the Acid liquor appears leſs unctuous and ſaponaceous.

A very good way to ſeparate this Oil more effectually from the Acid is to combine the whole with abſorbents, and abſtract the Oil again by diſtillation. By this means a very ſenſible quantity of Oil may be ſeparated that was not perceived before. On this occaſion it is proper to remark that the Oil thus united with the vegetable Acid is perfectly diſſolved by it; ſeeing it is thereby rendered miſcible with water, ſo that it doth not, like Alkaline ſoaps, in the leaſt obſcure its limpidity, or give it a milky caſt: for theſe aqueous, oily Acids are very tranſparent; eſpecially after they have ſtood for ſome time.

The air, that is diſcharged with impetuoſity in the operation, and muſt be let out, is loaded with many particles of Acid and Oil reduced to vapours, which it carries off; and by this means the quantity of the principles extracted from the mixt cannot be accurately determined: nor are the vapours, of which the veſſels remain full after the operation, any other than particles of Acid and Oil, which the violence of the fire hath rarefied exceedingly, and which do not eaſily condenſe.

If we diſtill in this manner a vegetable aromatic ſubſtance, which of courſe contains an Eſſential Oil, provided it hath not been previouſly extracted by the appropriated proceſs, this Eſſential Oil will riſe firſt, as ſoon as the diſtilling veſſel acquires the heat of boiling water: but its ſcent will not be near ſo ſweet or grateful, as if it were diſtilled in the manner before directed as propereſt for it. On the contrary, it will have an empyreumatic ſmell: becauſe in this way it is impoſſible to avoid ſcorching, and half-burning ſome of the matter diſtilled; eſpecially that part of it which touches the ſides of the retort. Moreover, the very ſame equable degree of heat can hardly be kept up with a naked fire. The Eſſential Oil therefore, though it riſes firſt, will not be pure, but contaminated with a mixture of the empyreumatic Oil that firſt comes over, and will be confounded therewith.

If a ſubſtance abounding with Fat Oil, that hath not been expreſſed from it, be diſtilled according to the preſent proceſs, it will yield no Fat Oil by diſtillation; but only much more of the firſt clear Oil, and of the ſecond thick Oil, than if all the Fat Oil it would have afforded had been firſt drawn off by expreſſion: for as the Fat Oil will not riſe in diſtillation, without a degree of heat greater than that of boiling water, neither can it endure ſuch a degree of heat without changing its nature, without loſing that mildneſs, and, in a great meaſure, that unctuoſity which is natural to it. It will therefore be confounded with the other empyreumatic Oil, which, in all probability, would itſelf be no other than a Fat Oil, if it could be wholly extracted, without the aid of fire, from the vegetable ſubſtances containing it.

Moſt vegetable ſubſtances, when diſtilled with a ſtrong fire, yield the ſame principles with that which we have choſen for an inſtance. Entire plants of this kind, thoſe from which the odorous principle, the Eſſential Oil, or the Fat Oil, hath been drawn, thoſe of which extracts have been made by infuſion or decoction, or the extracts themſelves; all ſuch matters being diſtilled yield a Phlegm, an Acid, a thin Oil, Air, and a thick Oil; and the products of their ſeveral analyſes differ from each other, only on account of the different quantity or proportion that each contains of the principles here enumerated.

But there are many other plants, which, beſides theſe ſubſtances, yield alſo a conſiderable quantity of a Volatile Alkaline Salt. This property is poſſeſſed chiefly by that tribe of plants which is diſtinguiſhed by having cruciform flowers; among which there are ſome that being analyzed greatly reſemble animal matters. We ſhall now analyze one of theſe; Muſtard-ſeed for inſtance.

PROCESS II.

To analyze a vegetable Subſtance which yields the ſame principles as are obtained from Animal matters: inſtanced in Muſtard-ſeed.

WITH an apparatus like that of the preceding proceſs, and with the ſame fire, diſtill Muſtard-ſeed. With a degree of heat, inferiour to that of boiling water, there will come over a phlegm ſomewhat coloured, and impregnated with a Volatile Alkaline Salt. With a degree of heat, greater than that of boiling water, the ſame kind of phlegm, impregnated with the ſame Salt, will continue to come over; but it will be much higher coloured, and will be accompanied with a light Oil. At this time a conſiderable quantity of air is diſcharged; with regard to which the ſame precautions muſt be taken as in diſtilling Guaiacum.

If the fire be gradually raiſed, there will come over a black thick Oil, lighter however than water; and at the ſame time vapours will riſe, and, condenſing on the ſides of the receiver, form into ſprigs or ramifications. This is a Volatile Alkaline Salt, in a concrete form, like that of Animals, as we ſhall hereafter ſee. Theſe vapours are much whiter than thoſe of Guaiacum.

When you have thus drawn off, with a very ſtrong fire, all the Volatile Alkali and thick Oil contained in the ſubject, there will be nothing left in the retort but a ſort of coal, from which a ſmall quantity of Phoſphorus may be obtained, provided the retort you employ for that purpoſe be good enough to ſtand a very violent heat.

OBSERVATIONS.

MUSTARD-SEED furniſhes us with an inſtance of a vegetable, from which we obtain, by analyzing it, the very ſame principles that animal matters yield. Inſtead of getting an Acid from it, we obtain only a Volatile Alkali; probably becauſe the Acid, which originally enters into the compoſition of this kind of vegetables, as well as of all others, undergoes in paſſing through their ſtrainers, and mixing with their juices, ſuch alterations as it ſuffers when it enters into the compoſition of animals: that is, it combines with ſome of their Earth and of their Oil, in ſuch a manner as to be changed into a Volatile Alkali, or at leaſt diſpoſed to be converted into one with the aid of fire.

We ſhall not here ſpeak of the manner of ſeparating and depurating the principles obtained by this proceſs; but reſerve it for the analyſis of animals, which is abſolutely the ſame. We ſhall content ourſelves with obſerving that the firſt Volatile Alkali, which riſes at the beginning of the operation together with the phlegm, in a degree of heat below that of boiling water, differs from that which doth not come over till towards the end of the diſtillation, when the laſt thick Oil aſcends. The different times, and different degrees of heat, in which theſe two Alkalis riſe, ſhew that the former exiſts actually and perfectly in the plant; but that the latter is generated during the diſtillation, and is the product of the fire, which combines together the materials whereof it is compoſed.

Vegetables, that thus yield a Volatile Alkali with a heat leſs than that of boiling water, irritate the organ of ſmelling, affecting it with a ſenſation of acrimony; and the effluvia, which riſe from them when bruiſed, make the eyes ſmart ſo as to draw tears from them in abundance. Several of theſe matters, being only bruiſed, efferveſce with Acids: effects producible only by a very Volatile Alkaline principle.

This is that Alkali, the lighteſt of all the principles that can be extracted from bodies, which riſes firſt in our diſtillation along with the phlegm, and with a degree of heat much inferiour to that of boiling water. As the phlegm with which it riſes is very copious, it is diſſolved thereby; which is the reaſon it doth not appear in a concrete form. To this water it gives a ſlight yellowiſh tinge, becauſe it is impure and oily. The ſaline Alkaline properties of this liquor have procured it the title of a Volatile Spirit. This Volatile Alkali, which exiſts naturally and perfectly formed in Muſtard-ſeed, Onions, Garlick, Creſſes, and other ſuch vegetables, conſtitutes a difference between them and animal ſubſtances, which contain only the materials requiſite to form a Volatile Alkali, but none ready formed, unleſs they have undergone the putrid fermentation.

The ſecond Volatile Alkali, which riſes in our diſtillation, but not without a very ſtrong degree of fire, and at the ſame time with the laſt thick Oil, ſeems to be a production of the fire; for if it were already formed in the mixt, as the other is, it would riſe with the ſame heat, and at the ſame time, being equally volatile. It is not impoſſible, however, that it may exiſt perfectly formed in the plant; but, having contracted an union with ſome Acid, and therewith compoſing an Ammoniacal Salt, it may by that means be hindered from riſing ſo readily as is agreeable to its natural volatility.

The Phoſphorus obtained by a violent fire, from the *caput mortuum* of this diſtillation, ſeems to throw

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a light of probability on this conjecture. There is certainly a great deal of Acid in the compoſition of Phoſphorus. Perhaps this Acid was originally combined with our ſecond Volatile Alkali, and formed therewith, as was ſaid, a ſort of Sal Ammoniac. Moreover, almoſt all the plants, that yield a Volatile Alkali by diſtillation, yield alſo a conſiderable quantity of Acid; which may perhaps be the remains of ſuch a Sal Ammoniac decompoſed by the operation. This is a ſubject for curious and uſeful enquiries. The ſecond Volatile Alkali appears in a concrete form, becauſe very little phlegm comes over along with it; ſo that the vapours thereof are not ſufficient to diſſolve it, as they did the firſt.

CHAP. VII.

OF THE SUBSTANCES OBTAINED FROM VEGETABLES BY COMBUSTION.

PROCESS I.

To procure a Fixed Cauſtic Alkaline Salt from a Vegetable ſubſtance, by burning it in the open air.

TAKE any vegetable matter whatever; ſet it on fire, and let it burn in the open air till it be wholly reduced to aſhes. On theſe aſhes pour a quantity of boiling water ſufficient to drench them thoroughly. Filter the liquor in order to ſeparate the earthy parts; and evaporate your lye to dryneſs, ſtirring it inceſſantly; and you will have a yellowiſh-white Salt.

Put this Salt in a crucible; ſet it in a melting furnace, and make a moderate fire, ſo as not to fuſe the Salt. It will turn firſt of a blue-grey colour, afterwards of a blue-green, and at laſt rediſh. Put on the dome of the furnace; fill it with coals; make your fire ſtrong enough to melt the Salt, and keep it in fuſion for an hour, or an hour and half. Then pour it into a heated metal mortar; pound it while it is red-hot; put it, as ſoon as poſſible, into a glaſs bottle, firſt made very hot and dry, and ſhut it up cloſe with a glaſs ſtopple rubbed with emery. By this means you will have the pure Fixed Alkali of the vegetable ſubſtance you burnt.

OBSERVATIONS.

BURNING a vegetable ſubſtance in the open air is a kind of violent and rapid analyſis made by fire, which ſeparates, reſolves, and decompoſes ſeveral of its principles.

When any wood or plant is laid on a quick fire, there aſcends from it immediately an aqueous ſmoke, which conſiſts of little more than phlegm; but this ſmoke ſoon becomes thicker and blacker: it is then pungent, draws tears from one's eyes, and excites a cough if drawn into the lungs with the breath. Theſe effects ariſe from its being replete with the Acid, and ſome of the Oil, of the vegetable converted into vapours. Soon after this the ſmoke grows exceeding black and thick: it is now ſtill more acrid, and the plant turns black. Its ſtrongeſt Acid and laſt thick Oil are now diſcharged with impetuoſity.

This rarefied Oil being heated red-hot ſuddenly takes fire and flames. The vegetable burns and deflagrates rapidly, till all its Oil is conſumed. Then the flame ceaſes; and nothing remains but a coal, like that found in a retort after all the principles of a plant have been extracted by the force of fire. But this coal having a free communication with the air, which is abſolutely neceſſary to keep a combuſtible burning, continues to be red, ſparkles, and waſtes till all its phlogiſton is diſſipated and deſtroyed. After this nothing remains but the Earth and Fixed Salt of the vegetable; which mixed together form what we call the Aſhes. Water, which is the natural ſolvent of Salts, takes up every thing of that kind that is contained in the aſhes; ſo that by lixiviating them, as directed, all the Salt is extracted, and nothing left but the pure earth of the mixt which is thus decompoſed.

The phenomena obſerved in the burning of a vegetable ſubſtance, and the production thereby of a Fixed Alkali, ſeem to prove that this Salt is the work of the fire; that it did not exiſt in the plant before it was burnt; that the plant only contained materials adapted to form this Salt; and that this Salt is no other than a combination of ſome of the Acid, united with a portion of Earth, by means of the igneous motion.

In the firſt place; a Fixed Alkali may be obtained by lixiviation from the aſhes of all vegetable matters that contain an Acid, Earth, and Phlogiſton, in due proportion. Thus Eſſential Salts; the ſubſtance of extracts made by trituration, infuſion, or decoction; wood coals burnt to aſhes; all yield a quantity of this Salt in proportion to the quantity of Acid and Earth contained in them.

Secondly; Fat, Eſſential, and Empyreumatic Oils afford, when burnt, ſuch a ſmall quantity of Fixed Alkali as is ſcarce perceptible; becauſe they contain but little Acid, and ſtill leſs Earth: and theſe ſame Oils, when rectified by repeated diſtillations, and then burnt, leave ſtill leſs of this Salt; becauſe they are ſeparated by rectification from moſt of the Acid, together with the ſmall matter of Earth contained in them.

Thirdly; thoſe vegetable matters which being analyzed furniſh a great deal of Volatile Alkali, yield but very little Fixed Alkali; becauſe a great deal of their Acid is employed in forming the Volatile Alkali, which is diſſipated by burning the plant: and for the ſame reaſon thoſe which in diſtillation afford only a Volatile Alkali, and no Acid, leave in their aſhes little or no Fixed Alkali, as is the very caſe with animal matters.

Fourthly, and laſtly; the aſhes of plants that have been long ſteeped in water, and from which infuſions and decoctions have been made, always contain the leſs Alkali the longer they have been infuſed or boiled, and the more water they were infuſed or boiled in; becauſe water diſſolves and carries off their Acid. It is for this reaſon that the aſhes of float-wood are much leſs ſaline than thoſe of green wood. Boerhaave aſſures us, in his Chymiſtry, that having exhauſted Roſemary by repeated decoctions, and having afterwards boiled the plant thus treated, the aſhes produced by it ſhewed not the leaſt ſign of a Fixed Alkali. He ſays that, in order to exhauſt thoroughly all the ſaline matters contained in Roſemary, he was obliged to decoct it no leſs than twenty times ſucceſſively, with freſh water every time, and never ceaſed boiling it in this manner, till he was ſure that the water, by boiling the plant in it for a long time, took up from it no kind of matter whatever that in the leaſt affected its purity: ſo that the water of his laſt decoction had abſolutely no ſmell, taſte, or colour; but was in ſhort preciſely the ſame as before he uſed it for the decoction. The ſame Author obſerves that his plant, after having been exhauſted in this manner, and having ſuffered ſuch continued boiling, retained nevertheleſs its perfect external form; that from being green at firſt it became brown, and ſunk to the bottom of the water, inſtead of floating thereon as it did before decoction.

If, in re-iterating this beautiful experiment of Mr. Boerhaave's, you ſhould not ſucceed as you expect, you muſt not therefore accuſe this great man of having been miſtaken on this occaſion; ſeeing it is very difficult, not to ſay impoſſible, to aſcertain exactly, from the account he hath given of his experiment, all that is neceſſary to its perfect ſucceſs: for he hath not ſpecified either the duration of the coctions which he made the Roſemary undergo, or the quantity of water he employed in each; whereas a difference in either of theſe may occaſion a vaſt difference in the reſult. It is evident that if five or ſix pounds of water be uſed for each coction of a pound of Roſemary, and be kept boiling for two or three hours, the plant will not be near ſo much exhauſted by being ſo treated, as if the ſame quantity thereof were kept boiling for ſeveral days in forty or fifty quarts of water.

Indeed, theſe points ſeem, in ſome meaſure, to be determined by what he ſays of the quality which the water of the laſt decoction ought to have. But the ſame objections occur here alſo; nay, the two circumſtances of the quantity of water and the duration of the boiling, have the greateſt influence here: for the more a plant is exhauſted of its Salts, the more difficult it becomes for the water to diſſolve and ſeparate the ſmall quantity thereof that remains united with the tenacious Oil; and conſequently it may happen that this laſt water, after the plant hath boiled in it five or ſix hours, ſhall appear inſipid, ſcentleſs, colourleſs; and yet that a much greater quantity of water, but reduced by longer boiling to the ſame quantity with that which hath been boiled but five or ſix hours, ſhall have acquired both taſte and colour; in a word, ſhew that it hath taken up ſome of the principles of the plant. It may alſo happen, that, a ſmall portion of ſaline matter being diffuſed through a large quantity of water, after long continued coction, ſhall not be perceptible either to the taſte or to the eye; but that the very ſame portion of ſaline matter ſhall become very ſenſible, when the quantity of water in which it is loſt, as it were, is ſufficiently leſſened by evaporation.

Hence, if we would make ſure of fulfilling the conditions required by Mr. Boerhaave, the laſt decoction of the plant muſt be made in a much greater quantity of water, and continued for a much longer time, than may perhaps be imagined, or perhaps eaſily determined; and this decoction being evaporated to any degree you pleaſe, muſt have neither taſte, ſmell, nor colour; in ſhort it muſt from firſt to laſt remain perfectly like pure water. In other words, it is very difficult to attain to any certainty in this matter.

Though what hath hitherto been ſaid, about procuring the Fixed Alkali of plants by combuſtion, ſeems to prove that this Salt is wholly the production of the fire, yet it muſt not be aſſerted that no part thereof pre-exiſted formally in the plant before it was burnt. On the contrary, it is certain that, amongſt the ſaline matters found in the compoſition of plants, there are true Neutral Salts whoſe baſis is a Fixed Alkali; but this Alkali being combined with an Acid diſcovers none of its properties, and never appears in its true form till the Neutral Salt of which it makes a part is decompoſed by combuſtion. The caſe of Sea-plants, all of which contain Sea-ſalt, and when burnt yield an Alkaline Salt perfectly reſembling the baſis of Sea-ſalt, ſeems to decide this point.

If, in lixiviating the aſhes of a plant, to diſſolve and waſh out its Alkali, you intend that nothing ſhould be left but an abſolutely pure earth, fit for making cupels, you muſt not be contented with one ablution only, even with a large quantity of water: becauſe the aſhes continue drenched with the water in which the Salts are diſſolved, and conſequently, when this water is evaporated, ſome of the Salts will be left with the earth. Therefore, if this be your view, you muſt waſh it three or four ſeveral times, uſing freſh water every time.

The water impregnated with the Alkali cannot be evaporated without a conſiderable loſs of Salt, eſpecially if it be violently boiled; becauſe the water with which it is cloſely united carries off part of it. In conſequence of this intimate union, it is very difficult, when the evaporation is near finiſhed, and but a little water left, to dry the Salt perfectly, becauſe it pertinaciouſly retains this laſt portion of humidity.

The Alkali obtained from the aſhes of a burnt plant is not perfectly pure: it is contaminated with a ſmall mixture of fatty matters, which were probably defended thereby againſt the action of the fire, and which render it ſomewhat ſaponaceous. In order to free it from this extraneous matter, and to render it very cauſtic, it muſt be calcined a long time in a crucible, but without melting it at firſt: becauſe it is with this Salt as with moſt metallic matters, which are ſooner and more eaſily deprived of their phlogiſton by being calcined without melting, provided they be comminuted into ſmall particles, than when they are in fuſion; all melted matters having but a ſmall ſurface expoſed to the air, by the contact of which the evaporation of any thing whatever is exceedingly promoted. It was for this reaſon we directed the Salt to be calcined for a long time in a crucible before melting it.

Mr. Boerhaave was very ſenſible of the utility of this calcination of the Alkali previous to its being melted, when in his Chymiſtry he ordered the aſhes containing this Salt to be put into a large earthen veſſel, kept red-hot for a conſiderable time, taking great care that the Salt do not melt. He takes notice,

tice, that, the longer the aſhes are calcined in this manner, the ſtronger is the Alkali obtained from them. This method is, in the main, the very ſame with that here preſcribed, and produces the ſame effect; becauſe the Alkali is equally well freed of the extraneous fatty matter, whether it be calcined before or after its ſeparation, provided it be not ſuffered to melt.

Mr. Boerhaave gives another reaſon for recommending care to be taken that the Fixed Alkali do not melt, while the aſhes are calcining to render it ſtronger and more cauſtic: for, if that ſhould happen, the melted mixture of the Salt and aſhes would produce a vitrified maſs, which would have none of the properties of the Salt.

PROCESS II.

To procure the Fixed Salt of a Plant, by burning it after the manner of Tachenius.

INTO an iron pot put the plant whoſe Salt you deſire to obtain in the manner of Tachenius, and ſet it over a fire, ſtrong enough to make its bottom red-hot; at the ſame time cover your plant with a plate of iron, that may lye immediately upon it in the pot. The plant will grow black, and ſmoke conſiderably; but will not flame, becauſe it hath not a ſufficient communication with the air. The black ſmoke only will eſcape through the interſtice left between the ſide of the pot and the rim of the plate; which, for that purpoſe, ſhould be made ſo as not to fit exactly into the pot. From time to time take up the iron plate, ſtir the plant, and cover it again immediately, to prevent its taking fire, or to ſmother it if it ſhould happen to flame: go on thus till the black ſmoke ceaſe.

Then take off the iron plate: the upper part of the half-burnt plant will take fire as ſoon as the air is admitted, conſume gradually, and be reduced to a white aſh. Stir your matter with an iron wire, that the undermoſt parts, which are ſtill black, may be ſucceſſively brought uppermoſt, take fire, and burn to white aſhes. Go on thus as long as you perceive the leaſt blackneſs remaining. After this, leave your aſhes ſome time longer on the fire; but ſtir them frequently, to the end that, if any black particles ſhould ſtill be left, they may be entirely conſumed.

Your aſhes being thus prepared, lixiviate them with ſeven times their quantity of water, made to ſimmer over the fire, and keep ſtirring it with an iron ladle. Then filter the liquor, and evaporate it to dryneſs in an iron pot, ſtirring it inceſſantly towards the end, leſt the matter, when it grows ſtiff, ſhould adhere too cloſely to the veſſel. When all the humidity is evaporated, you will have a Salt of a darkiſh colour, and alkaline nature; which you may melt in a crucible, and mould into cakes. This is the Fixed Salt of plants, prepared in the manner of Tachenius.

OBSERVATIONS.

THE Fixed Salt obtained from plants in the manner invented by Tachenius, and here deſcribed, is in many reſpects different from the Cauſtic Fixed Alkali extracted out of the aſhes of plants that have been conſumed by flaming in the open air. Tachenius's Salt is indeed of an Alkaline nature; but much weaker than a pure Fixed Alkali. It is not by far ſo cauſtic; it attracts the moiſture of the air much more feebly and ſlowly; it melts with a much ſmaller degree of heat; and it doth not make ſo ſtrong an efferveſcence with Acids. In ſhort, if you diſſolve it in water, evaporate the ſolution to a pellicle, and ſet it in a cool place, it will ſhoot into ſmall cryſtals; which is not the caſe with a pure Fixed Alkali.

Theſe ſeveral different effects, which characterize Tachenius's Salt, and diſtinguiſh it from the Cauſtic Fixed Alkali produced by burning a plant in the open air, prove that it is not a pure Alkali, but combined with certain ſubſtances that bring it nearer to the nature of a Neutral Salt, and place it, as it were, in the mid-way between ſuch a Salt and a true Alkali. If we reflect on the manner in which it is produced, it is eaſy to perceive what are thoſe ſubſtances that muſt be combined with it. It hath been ſhewn that plants, when analyzed, yield a great deal of Oil and of Acid. When they are burnt in the open air, all their Oil is diſſipated in ſmoke, or conſumed in flame. Great part of the Acid is likewiſe diſſipated, and the remainder combining with the Earth of the plant forms a Fixed Alkali.

When the ſame plants are analyzed, by diſtilling them in cloſe veſſels, the ſame principles are carried up by the action of the fire, forced to ſeparate from the fixed parts, and paſs over into the receiver in the form of vapours and of a liquid: but, when they are burnt in the manner of Tachenius, the Acid and Oil of the plant, as faſt as they are expelled by the action of the fire, are repelled by the iron cover, which, at the ſame time that it prevents the Oil from being entirely conſumed in flame, obliges theſe two ſubſtances to circulate, reverberates them on the reſt of the plant, and, in a manner, forces them to re-unite, in part, with that from which they were juſt before ſeparated.

A conſiderable quantity, therefore, of the Oil and Acid of the plant, muſt evidently combine, in this operation, with its Fixed Salt, as faſt as it is produced; and the properties above ſpecified are ow-

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ing to theſe two ſubſtances. Tachenius's Salt is, therefore, a Fixed Alkali, partly neutralized by ſome of the Acid of the plant, and rendered a little ſaponaceous by a portion of its Oil; whence it is much milder than a pure Fixed Alkali, and proper to be given internally, as an excellent remedy in ſeveral diſorders.

For the medicinal virtues of this Salt Mr. Boerhaave's Chymiſtry ought to be conſulted, as the Author was a very good judge of ſuch matters.

Tachenius's Salt may be converted into a Cauſtic Fixed Alkali, by freeing it from the Acid and from the Oil to which its particular properties are owing. For this purpoſe nothing more is requiſite than to calcine it for a long time in a crucible, ſtirring it frequently with an iron wire, and taking care not to melt it, till it have undergone the ſame changes, and ſucceſſively acquired the ſame colours, as our Fixed Alkali; and, when it becomes rediſh, melting it and keeping it in fuſion for an hour or two.

Hitherto no ſenſible difference hath been obſerved between the Cauſtic Fixed Alkalis obtained from different plants, when equally calcined; except that thoſe produced by Sea-plants have, as we ſaid before, the ſame properties as the Alkaline baſis of Sea-ſalt. Much the ſame thing may be ſaid of the Fixed Salts obtained from plants by Tachenius's method: for, though they be combined with a portion of the Acid and Oil of the plant, yet, as theſe principles have been expoſed to the action of a ſtrong fire, they are exceedingly altered, and almoſt wholly reduced to one and the ſame condition.

PROCESS III.

To render Fixed Alkalis very cauſtic by means of Lime. The Cauſtic Stone.

TAKE a lump of newly burnt quick-lime, that hath not yet begun to ſlake in the air: put it into a ſtone pan, and cover it with twice its weight of the unwaſhed aſhes of ſome plant, that are full of the Salt you deſign to render cauſtic. Pour on them a great quantity of hot water; let them ſteep in it five or ſix hours, and then boil them gently. Filter the liquor through a thick canvas bag, or through brown filtering paper ſupported by a linnen cloth.

Evaporate the filtered liquor in a copper baſon ſet over the fire; and there will remain a Salt, which muſt be put into a crucible ſet in the fire. It will melt, and boil for ſome time; after which it will be ſtill, and look like an Oil, or melted Fat. When it comes to this condition, pour it out on a very hot copper plate, and cut it into oblong tapering ſlips, before it grow hard by cooling. Put theſe ſlips, while they are ſtill hot, into a very dry glaſs bottle, and ſeal it hermetically. This is the *Cauſtic Stone*, or *Common Cauſtic.*

OBSERVATIONS.

THE deſign of this operation is to combine with the Fixed Alkali all the ſaline acrid parts of the quick-lime. This is to be effected only by diſperſing and diffuſing both thoſe ſubſtances in water, which is the proper ſolvent of all ſaline matters. Seeing, therefore, we muſt have an actual lixivium, it is needleſs to employ an Alkali already prepared and ſeparated from aſhes; for which reaſon we directed aſhes that are ſtill replete with Alkali to be uſed inſtead of a pure Alkali. By this means two ends are anſwered at once: the Salt contained in the aſhes is extracted from them, and combined with the moſt acrid, ſubtile, and ſaline parts of the lime.

The lye, when ſaturated with theſe two ſaline matters together, is vaſtly more acrid and cauſtic than if it contained but one of the two in a quantity equal to both. With this lye Soap is uſually made; becauſe the acuated Alkali contained in it hath a much greater effect on Oils than any other kind of Alkali. It alſo acts with incredible violence on all animal matters; which it diſſolves, divides, and, in ſome meaſure, deſtroys, with ſurpriſing efficacy and quickneſs.

For this reaſon it is impoſſible to filter it through a woollen or ſilken bag; for it will eat through them, or even reduce them to a pap, almoſt as ſoon as it touches them. Beſides, as the lye would diſſolve ſome part thereof, it would thence acquire a ſaponaceous quality, and ſo loſe much of its cauſtic nature. We muſt, therefore, neceſſarily uſe a filter made of vegetable matters, which reſiſt this deſtroying Salt much better than animal matters.

An Alkali thus acuated by quick lime attracts and retains humidity more ſtrongly than any other kind of Alkali, even the perfecteſt and beſt calcined. For this reaſon it is almoſt impoſſible to dry it thoroughly in the baſon wherein you evaporate the lixivium.

To the moiſture ſtill left in it muſt be attributed its boiling when it begins to melt in the crucible. When all the humidity is diſſipated, the fuſed Salt remains ſmooth and unruffled, like wax melted with a gentle heat.

This cauſtic Salt is vaſtly more fuſible than the common Alkalis. It ſcarce grows red before it flows like wax. When it is once in quiet fuſion, all the humidity that occaſioned the boiling obſerved at firſt being diſſipated, it is as cauſtic as it can be made. It is then time to pour it out, and to cut it into long narrow ſticks, fit for the uſe of Surgeons, who apply it to eat away calloſities and excreſcences, and to open iſſues. On this account it is called the *Cauſtic Stone.* The operation of this Salt is ſo quick, that, in a very ſhort time, it produces on the ſkin a ſenſation like that of fire.

As this Salt grows ſurpriſingly ſoon moiſt in the air, and loſes its virtue when ſo moiſtened, it is neceſſary to ſhut it up, while it is ſtill hot, in a very dry bottle, which muſt be immediately ſtopped with a glaſs ſtopple rubbed with emery, or elſe with a ſound cork and then dipt in pitch. In ſpite of all theſe precautions, it can ſcarce be kept five or ſix months in full vigour; eſpecially if the bottle be ſometimes opened in the mean while. We ſhall not attempt to explain here why an Alkali becomes ſo violently cauſtic by being combined with quick-lime. This queſtion ſeems to be one of the moſt ſubtile, and the moſt difficult to anſwer, in all Chymiſtry. It depends on the cauſe of the Alkaline properties of lime; and can hardly be reſolved till we attain a further inſight into the nature of that ſubſtance than we have yet got.

PROCESS IV.

The Analyſis of Soot.

TAKE wood-ſoot from a chimney under which no animal matter hath been dreſſed or burnt: put it into a glaſs retort ſet in a reverberating furnace; lute on a receiver, and begin to diſtill with a degree of heat ſomewhat leſs than that of boiling water. A conſiderable quantity of limpid phlegm will come over. Keep the fire in the ſame degree as long as any of this phlegm riſes; but encreaſe it when the drops begin to come ſlow: and then there will aſcend a good deal of a milky water. When this water ceaſes to run, change the receiver, and increaſe your fire a little: a yellow Volatile Salt will riſe, and ſtick to the ſides of the receiver. The fire ought now to be very fierce, and, if ſo, will force up at the ſame time a very thick black Oil. Let the veſſels cool: you will find a ſaline matter riſen into the neck of the retort, which could not paſs over into the receiver: in the bottom of the retort will be a *caput mortuum*, or black charred ſubſtance, the upper part of which will be cruſted over with a ſaline matter, like that in the neck of the retort.

OBSERVATIONS.

THE preceding analyſes ſhewed what principles are obtained from vegetable ſubſtances without the aid of fire; thoſe which the heat of fire raiſes and carries over out of one cloſe veſſel into another; and, laſtly, thoſe that remain fixed after the vegetable hath been thoroughly charred, either in a cloſe veſſel, or in the open air: nothing therefore remained, to finiſh the ſubject of vegetable principles, but to examine thoſe which fire raiſes, in the form of vapours, ſmoke, and flame, from a vegetable matter burnt and conſumed in the open air. Every body knows that Soot conſiſts only of theſe principles, collected in the ſhafts of chimneys, which ſerve as alembics for this ſort of diſtillation in the open air. By analyſing Wood-Soot, therefore, we ſhall diſcover the principles we are in queſt of. The proceſs we have given for that purpoſe is taken from Boerhaave's Chymiſtry, where we find it deſcribed with great exactneſs and preciſion.

As we are at preſent enquiring into the nature of vegetables only, it is evidently neceſſary that we chuſe a Soot produced by burning vegetables alone. Soot, though dry in appearance, contains nevertheleſs much humidity, as appears from this analyſis; ſeeing there comes over at firſt a conſiderable quantity of phlegm, that doth not ſeem to be impregnated with any principle, except perhaps an extremely ſubtile, ſaline and oily matter, that communicates to it a diſagreable ſmell, from which it cannot by any means be entirely freed.

The white milky liquor, which follows this firſt phlegm, is ſtill water, but much more impregnated with ſaline and oily parts than the former. By its ſmell, which is exceeding quick and pungent, we may judge it contains much Volatile Alkali; and accordingly, when re-diſtilled by itſelf, it yields a Volatile Spirit, and a Volatile Salt in a concrete form. With regard to its white colour, it is occaſioned by the oily parts which are diffuſed and ſuſpended, but not diſſolved, in the water. When this ſecond liquor is come off, there aſcends a Volatile Alkali in a dry form, and a very thick black Oil; becauſe there is not moiſture enough left to diſſolve theſe principles, or rather to divide and diſperſe them.

The Volatile Alkali obtained from Soot is, in a double reſpect, the product of the fire. In the firſt place, though it derives its origin wholly from wood, or other vegetables, which, when diſtilled in cloſe veſſels, yield no Volatile Alkali at all, yet it produces ſuch a Salt when analyzed in the preſent manner: whence it muſt be inferred that the principles of thoſe vegetables are metamorphoſed into a Volatile Alkali, by being burnt in the open air, and ſublimed in the form of Soot. Secondly, though Soot when analyzed yields a great deal of this Salt, yet this Salt doth not formally pre-exiſt therein; for it doth not riſe till after the phlegm, nor without a very conſiderable degree of heat: therefore Soot contains only the materials neceſſary to form this Salt; therefore the perfect combination of this Salt requires that the force of fire be applied a ſecond time; therefore it is, as was ſaid, doubly the product of the fire.

The ſaline matter which we find ſublimed into the neck of the retort, and which alſo forms the cruſt that covers the *caput mortuum* of the Soot, appears by all Chymical trials to be an Ammoniacal Salt; that is, a Neutral Salt conſiſting of an Acid and a Volatile Alkali. This Ammoniacal Salt riſes only into the neck of the retort, and doth not come over into the receiver; becauſe it is but ſemi-volatile. We ſhall treat more at large of the production of a Volatile Alkali, and of this Ammoniacal Salt, when we come to the analyſis of Animals, and the article of Sal Ammoniac.

The charred matter that remains in the retort after diſtillation, being burnt in the open air, is reduced to an exceeding fixed white earth. As this fixed matter was part of that very Soot, which was ſublimed to a great heighth while the vegetable was burning; this is a proof of what we advanced before, that the moſt fixed matters are capable of ſublimation, when united with volatile ſubſtances; eſpecially when they are expoſed at the ſame time to the combined action of air and of fire.

CHAP. VIII.

THE ANALYSES OF SOME PARTICULAR SUBSTANCES BELONGING TO THE VEGETABLE KINGDOM.

PROCESS I.

Analyſis of the natural Balſams: inſtanced in Turpentine.

INTO a cucurbite put as much rain-water as will fill about a fourth part of its cavity, and pour into it the Turpentine you intend to analyze. Cover the cucurbite with its head, and lute it on with ſlips of ſized paper or wet bladder. Set your alembic in a ſand-heat; lute on a long-necked receiver; and give a gradual fire till the water in the cucurbite boil. There will come over into the receiver a good deal of phlegm, which, by little and little, will become more and more acid; and at the ſame time there will riſe a great quantity of an æthereal Oil, extremely light, fluid, and as limpid and colourleſs as water.

When you obſerve that no more Oil comes off, unlute your veſſels; and in the receiver you will find an acidulated water, and the æthereal Oil floating on it. Theſe two liquors may be eaſily ſeparated from each other, by means of a glaſs funnel.

In the cucurbite will be left ſome of the water you put in, together with the remainder of your Turpentine; which, when cold, inſtead of being fluid as it was before diſtillation, will be ſolid, and of the conſiſtence of a reſin, and is then called *Roſin.*

Put this reſiduum into a glaſs retort, and diſtill it in a reverberatory with a naked fire, gradually encreaſed according to the general rule for all diſtillations. At firſt, with a degree of heat a little greater than that of boiling water, you will ſee two liquors come over into the recipient; one of which will be aqueous and acid, the other will be a tranſparent, limpid, yellowiſh Oil, floating on the acid liquor.

Continue your diſtillation, increaſing your fire from time to time, by ſlow degrees. Theſe two liquors will continue to come off together; and the nearer the operation draws to its end, the more acid will the aqueous liquor become, and the thicker and deeper coloured will the Oil grow. At laſt the Oil will be very thick, and of a deep rediſh-yellow colour. When nothing more aſcends, unlute your veſſels: in the retort you will find only a very ſmall quantity of a charred, light, friable ſubſtance,

OBSERVATIONS.

ALL Natural Balſams, as well as Turpentine, are oily, aromatic matters, which flow in great quantities from the trees containing them, either ſpontaneouſly, or through inciſions made on purpoſe. As theſe matters have a ſtrong ſcent, it is not ſurpriſing that they ſhould greatly abound with Eſſential Oils. They may even be conſidered as Eſſential Oils, that naturally, and of their own accord, ſeparate from the vegetables in which they exiſt.

Indeed theſe Natural Balſams differ, in this alone, from the Eſſential Oils obtained out of plants by diſtillation, that the former contain a greater proportion of Acid; and, for that reaſon, are thicker than Eſſential Oils diſtilled with the heat of boiling water. But it hath been ſhewn that theſe ſame diſtilled Eſſential Oils, though ever ſo fluid and light

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at firſt, gradually loſe their tenuity as they grow old, and at laſt become conſiderably thick. On that occaſion we obſerved that they are thus changed, becauſe the lighteſt, moſt fluid, and leaſt acid parts are little by little diſſipated and evaporated; ſo that at laſt there remains only the thickeſt and heavieſt part, which owes theſe qualities to the Acid wherewith it is over-doſed.

Hence it follows that Natural Balſams, and Eſſential Oils grown thick with age, are exactly one and the ſame thing. Accordingly we ſee that fire and diſtillation produce the ſame effects on both. The rectification of an Eſſential Oil, thickened by keeping, is nothing but a decompoſition thereof, by ſeparating, with the heat of boiling water, all thoſe parts that are light enough to riſe with that degree of heat, from what is ſo loaded with Acid as to remain fixed therein.

This operation is therefore preciſely the ſame as our firſt diſtillation of Balſams with the heat of boiling water, by which the Eſſential Oil contained in them is drawn off. The reſidues of theſe two operations are alſo the ſame: each of them is a thick Oil, loaded with Acid, that is wholly, or nearly, deprived of the principle of odour peculiar to the original vegetable, and requires a degree of heat greater than that of boiling water to decompoſe it, by ſeparating part of the Acid from the Oil; which will be rendered ſtill the more fluid, the more the thickening Acid is ſeparated from it by repeated diſtillations.

The newer Natural Balſams are, the thinner they are, and the more Eſſential Oil do they yield; and this Eſſential Oil, like all others, grows thick in time, and at laſt turns again to an actual Balſam.

Theſe Balſams, by being long expoſed to the heat of the ſun, acquire ſuch a conſiſtence as to become ſolid. They then take another name, and are called *Reſins*. Reſins yield much leſs Eſſential Oil when diſtilled, than Balſams do. Hence it follows that Reſins are to Balſams, what Balſams are to Eſſential Oils. All theſe effects are produced by the cauſes aſſigned above, and confirm the analogy we have eſtabliſhed.

We have no other obſervations to make on this analyſis of Turpentine, except that when Roſin is diſtilled in a retort with a naked fire, the operation muſt be carried on very ſlowly, and the fire duly governed: for the matter is apt to ſwell, and to riſe in ſubſtance into the receiver without being at all decompoſed. In order to avoid this inconvenience, it is adviſeable to make uſe of a long-bodied retort, ſuch as is known by the name of the *Engliſh Retort*.

If you ſtop the diſtillation of Roſin about mid-way, or when the Oil that comes over begins to grow thick, you may by changing the receiver keep the firſt Oil apart: it is pretty fluid, and of a middle nature between the æthereal Oil obtained with the heat of boiling water, and the laſt thick Oil that doth not riſe till towards the end of the diſtillation. This laſt thick Oil is that which Mr. Homberg fired with concentrated Oil of Vitriol.

If we examine the matter contained in the retort, when the diſtillation is thus ſtopped ſhort, it appears, when cold, in the form of a ſolid ſubſtance, almoſt perfectly diaphanous, of a deep rediſh-yellow colour, and friable: It is known by the name of *Colophony*.

This analyſis of boiled Turpentine, is a ſpecimen of the analyſis of almoſt all other reſins; ſo that what hath been ſaid on this occaſion is, in a manner, general, and applicable to other decompoſitions of the ſame kind. We ſhall now proceed to examine ſome other oily matters, which exhibit peculiar phenomena, and do not come under the general rules.

PROCESS II.

The Analyſis of Reſins: inſtanced in Benjamin. The Flowers and Oil of Benjamin.

INTO a pretty deep earthen pot, having a border or rim round its mouth, put the Benjamin you intend to analyze. Cover the pot with a large conical cap of very thick white paper, and ty it on under the rim. Set your pot in a ſand-bath, and warm it gently till the Benjamin melt. Continue the heat in this degree for an hour and half. Then unty the paper cap and take it off, ſhaking it as little as poſſible. You will find all the inſide of the cap covered with a great quantity of beautiful, white, ſhining Flowers, in the form of little needles. Bruſh them off gently with a feather, put them into a bottle, and ſtop it cloſe.

As ſoon as you take off the firſt cap, cover your pot immediately with a ſecond like the former. In this manner go on till you perceive the Flowers begin to grow yellowiſh; and then it is proper to deſiſt.

The matter left in the pot will be blackiſh and friable when cold. Pulverize it; mix it with ſand; and diſtill it in a glaſs retort with a graduated heat. There will come over a light Oil, of a fragrant ſcent, but in very ſmall quantity; a little of an acid liquor, and a great quantity of a red thick Oil. There will be left in the retort a charred, ſpungy ſubſtance.

OBSERVATIONS.

ALL oily matters, that are naturally thick and in a concrete form, reſemble each other in this, that they derive theſe qualities from an Acid combined with them. But they nevertheleſs differ greatly from one another in many reſpects. The quality, the quantity, of the Acid to which they owe their conſiſtence, and the manner in which it is united with them, diverſify them a thouſand ways.

In the preceding proceſs we advanced that Natural Balſams are diſtinguiſhed from Reſins by their containing ſo much more Oil, in proportion to their Acid, as ſuffices to render them almoſt fluid. For this reaſon they yield an Eſſential Oil: whereas Reſins, on the contrary, are ſolid; all their Oil being loaded and weighed down with a great quantity of Acid, ſo that no Eſſential Oil can be drawn from them.

We obſerved at the ſame time, that, when all the Eſſential Oil contained in a Natural Balſam is drawn off with the heat of boiling water, the reſidue takes a ſolid conſiſtence, and reſembles a Reſin. In fact almoſt all Reſins yield, by diſtillation, the ſame principles as that reſidue; that is, an Oil of a midling nature between Eſſential Oils and thick Oils, in point of lightneſs and fluidity; the whole being always accompanied with an Acid diffuſed in phlegm.

In conſequence hereof the analyſis of Benjamin, deſcribed in the proceſs, appears to vary very much from that of other Reſins: for here we ſee a volatile matter in a concrete form; namely, the white Flowers that riſe firſt; which doth not uſually occur in the analyſis of Reſins. Yet, if we examine the matter, we ſhall be convinced that it is very analogous to one of the principles obtainable from all Reſins; that indeed it differs therefrom in ſome of its properties, particularly in its external form; but that it is in reality the very ſame.

In fact the Flowers of Benjamin are no other than an Oily Acid nearly of the ſame nature with thoſe obtained from all other vegetable ſubſtances; but which, inſtead of being liquid like them, appears in a dry concrete form, and in a manner cryſtallized. It probably derives this property from its Oil being combined with its Acid, either in greater quantity, or in a more intimate manner, than in the reſt, and ſo ſtrongly united therewith as not to be ſeparated from it by a ſubliming heat; or from hence, that the compound, of which it is a part, contains too little phlegm to diſſolve it; or elſe, that it is hindered from diſſolving therein by the Oil with which it is combined. Perhaps all theſe cauſes may concur together in producing its concrete form.

The ſaline character of this ſubſtance appears chiefly from its being ſoluble in water: but the water muſt be very hot, and even boiling, before it will effect this ſolution; and when it cools, the Salt ſhoots into fine needles at the bottom. This phenomenon directs us to a method of ſeparating it from Benjamin without ſublimation.

For this purpoſe the Reſin muſt be boiled in water: the water will then diſſolve the Salt; and, as it cools, the Salt will cryſtallize, and may be eaſily collected. But as the Oil, with which the Acid is combined, hinders the water from diſſolving it ſo eaſily as it otherwiſe would, we cannot obtain quite ſo much of it, from the ſame quantity of Benjamin, by decoction as by ſublimation; the laſt portions thereof being united with a great quantity of Oil, which defends them againſt the action of the water. This Salt diſſolves readily in Spirit of Wine, on account of the Oil combined with it. A courſe of well connected experiments might give us a much greater inſight into its natural properties than we can now boaſt of.

Benjamin yields a much ſmaller quantity of fluid Oil by diſtillation than other Reſins do; becauſe the greateſt part of its Oil is employed in the compoſition of its oily, volatile, acid Salt. The thick Oil drawn from this Reſin, is thicker than that obtained from any other Reſin, and even fixes like butter when cold; nor can we get more than a very ſmall quantity of Acid in a diſtinct liquor. All theſe effects depend on what we mentioned above in relation to its ſaline flowers; to wit, the peculiar and intimate union between the Acid and Oily parts of this Reſin, ſo that the fire cannot ſo eaſily or ſo perfectly disjoin them as it doth thoſe of other Reſins.

Benjamin, when diſtilled, leaves in the retort much more of a charred coal than is left by moſt other reſinous matters. This may be owing to the conſiderable quantity of earthy matter which it contains, and which, perhaps, may alſo be one of the cauſes that contribute to give its Salt a concrete form.

REFLECTIONS

ON THE NATURE AND PROPERTIES OF CAMPHOR.

WE do not propoſe to give an analyſis of this ſingular body; becauſe hitherto there is no proceſs known in Chymiſtry by which it can be decompoſed. We ſhall therefore content ourſelves with reciting its principal properties, and making a few reflections on its nature.

Camphor is an oily concrete ſubſtance; a kind of Reſin, brought to us from the Iſland of Borneo, but chiefly from Japan. This ſubſtance reſembles Reſins, in being inflammable, and burning much as they do; it is not ſoluble in water, but diſſolves entirely and perfectly in Spirit of Wine; it is eaſily ſeparated again from this menſtruum, as all other oily matters are, by the addition of water; it diſſolves both in expreſſed and in diſtilled Oils; it hath a very ſtrong aromatic ſmell. Theſe are the chief properties which Camphor poſſeſſes in common with Reſins : but in other reſpects it differs totally from them ; eſpecially in the following particulars.

Camphor takes fire and flames with vaſtly more eaſe than any other Reſin. It is ſo very volatile, that it vaniſhes entirely in the air, without any other heat than that of the atmoſphere. In diſtillation it riſes entire, without any decompoſition, or even the leaſt alteration. It diſſolves in concentrated mineral Acids ; but with circumſtances very different from thoſe that attend other Oily or Reſinous ſubſtances. The diſſolution is accompanied with no effervescence, no ſenſible heat ; and conſequently can produce no inflammation. Acids do not burn, blacken, or thicken it, as they do other Oily matters ; on the contrary, it becomes fluid, and runs with them into a liquor that looks like Oil.

Camphor doth not, like other Oily matters, acquire a diſpoſition to diſſolve in water by the union it contracts with Acids ; though its union with them ſeems to be more intimate than that of many Oily matters with the ſame Acids. On the contrary, if a combination of Camphor and an Acid be diluted with water, theſe two ſubſtances inſtantly ſeparate from each other : the Acid unites with the water, and the Camphor, being entirely diſengaged from it, ſwims on the ſurface of the liquor. Neither Volatile Alkalis, nor the moſt cauſtic Fixed Alkalis, can be brought into union with it ; for it always eludes their power.

Notwithſtanding theſe wide differences between Camphor and all other Oily and Reſinous ſubſtances, the rule, that Acids thicken Oils, ſeems to be ſo univerſal, and ſo conſtantly obſerved by nature, that we cannot help thinking this ſubſtance, like all the reſt, is an Oil thickened by an Acid. What Oil ? What Acid ? and how are they ? This is a ſubject for very curious enquiries.

With a yellow Oil drawn from wine, and an acid vinous Spirit, of which we ſhall ſay more under the article of Æther, Mr. Hellot made a kind of artificial Camphor; a ſubſtance having the odour, ſavour, and inflammability of Camphor; an imperfect Camphor. True Camphor hath the levity, the volatility, and the inflammability of Æther. Can it be a ſubſtance of the ſame nature with Æther, a kind of ſolid Æther, an Æther in a concrete form?

PROCESS III.

The Analyſis of Bitumens: inſtanced in Amber. The Volatile Salt and Oil of Amber.

INTO a glaſs retort put ſome ſmall bits of Amber, ſo as to fill but two thirds of the veſſel. Set your retort in a furnace covered with its dome; fit on a large glaſs receiver; and, beginning with a very gentle heat, diſtill with degrees of fire. Some phlegm will firſt come off, which will gradually grow more acid, and be ſucceeded by a Volatile Salt, figured like fine needles, that will ſtick to the ſides of the receiver.

Keep the fire up to this degree, in order to drive over all the Salt. When you perceive that little or none riſes, change the receiver, and increaſe your fire a little. A light, clear, limpid Oil will aſcend. As the diſtillation advances, this Oil will grow higher coloured, leſs limpid, and thicker; till at laſt it will be opaque, black, and have the conſiſtence of Turpentine.

When you perceive that, though the retort be red-hot, nothing more comes off, let the fire go out. You will have in the retort a black, light, ſpungy coal. If you have taken care to ſhift the receiver, from time to time, during the diſtillation of your

Oil, you will have ſundry ſeparate portions thereof, each of which will have a different degree of tenuity or thickneſs, according as it came over at the beginning, or towards the end of the diſtillation.

OBSERVATIONS.

THE ſubſtance of which we have here given the analyſis, together with all others of the ſame, that is, of the Bituminous kind, is by moſt Chymiſts and Naturaliſts claſſed with Minerals: and ſo far they are right, that we actually get theſe mixts, like other minerals, out of the bowels of the earth, and never procure them immediately from any vegetable or animal compound. Yet we have our reaſons for acting otherwiſe, and for thinking that we could not, in this work, place them better, than immediately after thoſe vegetable ſubſtances which we call Reſins.

Several motives determine us to proceed in this manner. The analyſis of Bitumens demonſtrates, that, with regard to the principles of which they conſiſt, they are totally different from every other kind of mineral; and that, on the contrary, they greatly reſemble vegetable Reſins in almoſt every reſpect. In ſhort, though they are not immediately procured from vegetables, there is the greateſt reaſon for believing that they were originally of the vegetable kingdom, and that they are no other than reſinous and oily parts of trees or plants, which by lying long in the earth, and there contracting an union with the mineral Acids, have acquired the qualities that diſtinguiſh them from Reſins.

Mineralogiſts know very well that we find, every where in the earth, many vegetable ſubſtances, that have lain very long buried under it, and frequently at a conſiderable depth. It is not uncommon to find, under ground, vaſt beds of foſſile trees, which ſeem to be the remains of immenſe foreſts: and Bitumens, particularly Amber, are often found among this ſubterraneous wood.

Theſe conſiderations, joined to proofs drawn from their analyſis, make this opinion more than probable: nor are we ſingular in maintaining it, as it is adopted by many able modern Chymiſts.

The analyſis of Amber, above deſcribed, may ſerve as a general ſpecimen of the decompoſition of other Bitumens: with this ſingle difference, that Amber is the only one among them which yields the Volatile Salt aforeſaid; and this determined us to examine it preferably to any other. As for the reſt, they all yield a phlegm, an acid liquor, and an Oil; which is thin at firſt, but grows thicker and thicker as the diſtillation draws towards an end. It muſt be underſtood, however, that theſe Acids and theſe Oils may differ, according to the nature of the Bitumens from which they are drawn; juſt as the Phlegm, the Acid, and the Oil, reſulting from the decompoſition of Reſins, differ in quantity and quality, according to the nature of the Reſins from which they are procured.

The principal differences obſerved between Reſins and Bitumens are theſe: the latter are leſs ſoluble in Spirit of Wine; have a peculiar ſcent, which cannot be accurately deſcribed, and of which the ſenſe of ſmelling only can judge; and their Acid is ſtronger and more fixed. This laſt property is one of the motives which induce us to think that beſides the vegetable Acid, originally combined with the Reſinous or Oily matter now become a Bitumen, a certain quantity of mineral Acid hath, in a courſe of time, been ſuperadded to conſtitute this mixt. We ſhall preſently ſee that the fact is certainly ſo, in the caſe of Amber at leaſt.

Almoſt all Authors who mention the analyſis of Amber, have given different accounts of the Volatility of its Salt, and of the time of the diſtillation when it begins to riſe. Some make it aſcend immediately after the firſt acid phlegm. Others ſay that it doth not begin to appear till after the firſt thin Oil; and others again affirm that it comes over with the laſt thick Oil. Mr. Bourdelin, who hath examined this matter to the bottom in a Memoir on the analyſis of Amber given in to the Academy, very judiciouſly remarks, that the different reſults, which thoſe Chymiſts met with in analyzing our mixt, aroſe wholly from the different manner wherein each conducted his fire during the operation.

It is certain that ſuch a cauſe is capable of producing vaſt differences: for when fire is haſtily applied, or made too violent, it not only confounds and tumultuouſly mingles the principles of the body to be analyzed, but it even frequently drives up the entire ſubſtance itſelf out of the retort into the receiver, without decompoſing it at all. This is really ſo in the caſe of Amber, and of almoſt all compound ſubſtances that are not extremely fixed.

It ought therefore to be obſerved, as a general and important rule in every analyſis, to adminiſter the fire exceeding ſlowly and cautiouſly, as one can never err on that ſide; and to increaſe it only by ſuch degrees as appear neceſſary for carrying on the diſtillation. By obſerving this method, an accurate analyſis will be attained: by this means the Salt of Amber will riſe before the Oil; whereas, if a degree of heat ſufficient to raiſe the thin Oil, or even the thick Oil, be applied at firſt, the Salt will accordingly come over with the one or the other of theſe Oils.

Chymiſts remained a long time unacquainted with the nature of this Salt of Amber, and Authors of the greateſt name agreed as little on this point, as on that juſt mentioned. Some aſſerted it to be a Volatile Salt of the ſame kind with that which is obtained from animal ſubſtances; that is, a Volatile Alkali: others, on the contrary, pretended that it was an Acid of a ſingular nature.

It is very ſupriſing that ſuch Authors ſhould diſagree on ſuch a point; conſidering how eaſily it may be aſcertained whether this Salt be really an Acid or an Alkali. Mr. Bourdelin juſtly decides the queſtion in favour of thoſe who affirm it to be an Acid. In fact it hath all the properties of an Acid: it hath the taſte of one, forms Neutral Salts with Alkalis, and differs from the moſt unqueſtionable Acids in this alone, that, being combined with a portion of Oil and a ſmall quantity of earth, theſe give it a concrete form; which is not a ſolitary caſe in Chymiſtry, as is evident from Cream of Tartar. With regard to its Volatility, there is nothing in that repugnant to the properties of its conſtituent principles; ſeeing the Acid and the Oil predominant therein may eaſily be ſuppoſed to communicate their Volatile nature to the ſmall portion of earth with which they are combined.

Thoſe Chymiſts, who looked upon the Salt of Amber as a Volatile Alkali, either did not examine it thoroughly, but contented themſelves with its firſt appearance, in which it reſembles the Volatile Salt of animals, or elſe were led into the errour by ſome particular circumſtances. We know, for example, that animal as well as vegetable ſubſtances are dug out of the earth. The inſects, ſometimes found incloſed in lumps of Amber, ſufficiently prove this. Perhaps they made their experiments on ſuch pieces of Amber; or elſe, that which they uſed might be mixed with ſome animal ſubſtance not very perceptible. In ſuch a caſe it would be no wonder if the Volatile Salt obtained ſhould ſhew ſome tokens of an Alkali: for the Volatile

Alkali ariſing from the animal matter would only be mixed, not combined, with the Salt of the Amber; as the great quantity of Oil, in which both theſe Salts are intangled, would hinder them from diſſolving each other, and forming ſuch a Neutral Salt as would be produced in other circumſtances.

The acid or alkaline nature of the Salt of Amber was not the only point that remained to be diſcuſſed on this occaſion. Its acid quality being once clearly aſcertained, the nature of this Acid was next to be determined. This is the object chiefly aimed at in Mr. Bourdelin's Memoirs, and his diſcovery thereof is unqueſtionably one of the fineſt, and at the ſame time one of the moſt difficult, that could be attempted with regard to this Bitumen.

It appears plainly from ſeveral experiments, of which we have given an account in the courſe of this work, that the ſtrongeſt mineral Acids, by being combined with any Oily matter, are ſo vaſtly altered, and ſo ſtrangely diſguiſed, that we not only are incapable of diſtinguiſhing what they are, but even can hardly avoid decompoſing, and partly deſtroying them, by thoſe very operations which ſeem the beſt adapted to ſeparate them from the Oil in which they are inviſcated. Mr. Bourdelin had all theſe difficulties to ſurmount, and inceſſantly met with new obſtacles in that troubleſome fatty matter, which, like an impenetrable veil, concealed from his view the Acid whoſe nature he wanted to diſcover. But at laſt, by dint of manifold experiments, he happily gained his end. Two parts of pure Nitre, unadulterated with the leaſt particle of Sea-ſalt, and one part of Amber, pulverized and mingled together, procured him, by deflagration, a Salt partly neutral and partly alkaline; which being lixiviated, and ſet to evaporate ſpontaneouſly, there formed at the bottom a reſidence of a mucilaginous, pappy, whitiſh matter, amongſt which he could diſtinguiſh cryſtals, that were very tranſparent, regularly figured, of a cubical form, but rather oblong; ſo that they repreſented little oblong ſquares moſt exactly formed, and about half a line thick.

As theſe cryſtals perfectly reſembled, in their figure, the Neutral Salt produced by a combination of the Acid of Sea-ſalt with the Alkaline baſis of Nitre; this was a proof to Mr. Bourdelin that the Acid of Amber is of the ſame kind, or rather exactly the ſame, with that of Sea-ſalt. The Nitre being alkalizated by means of the phlogiſton of the Amber, the Acid of the Bitumen, finding this Alkali a proper baſis to fix in, unites with it, and by that means is enabled to reſiſt the action of the fire, ſo as not to be carried off by it.

On the other hand, it is ſeparated from the fat matter by which it was maſked before; for by the help of this fat matter the Nitre is alkalizated. The Acid, having by this means recovered all its properties, begins to diſcover them, as hath been ſaid, by the figure it conſtantly gives to the cryſtals of the Neutral Salt which it helps to conſtitute.

Moreover, this Neutral Salt hath all the eſſential properties of Sea-ſalt. It hath its taſte; it decrepitates in the ſame manner on live coals; if Oil of Vitriol be poured on it, white vapours ariſe, which have the ſmell of Spirit of Salt, and are an actual Spirit of Salt. Laſtly, it makes a white precipitate of Mercury diſſolved in Spirit of Nitre, and a *luna cornea* of Silver diſſolved in the ſame Spirit; which laſt proofs would alone be ſufficient to eſtabliſh Mr. Bourdelin's opinion, though we had no other.

It were to be wiſhed that the experiments which Mr. Bourdelin hath made on Amber were alſo made on other Bitumens. There is reaſon to think they would be found to contain either the Marine or the Vitriolic Acid: for though they do not yield a Volatile Salt, as Amber doth, in diſtillation, yet the Acids obtained from them are very ſtrong, and appear, as we ſaid before, to have a mineral origin. Mr. Geoffroy obſerved that Amber being pulverized, and infuſed in hot water, parts with its Salt in the ſame manner as Benjamin does; which gives room to ſuſpect that Amber is to Bitumens what Benjamin is to Reſins.

PROCESS IV.

The analyſis of Bee's-Wax, and ſuch Oily Compounds as are analogous to it.

MELT the Wax you intend to analyze, and mix with it as much fine ſand as will make it into a ſtiff paſte. Put this paſte in little bits into a retort, and diſtill as uſual, with a graduated fire, beginning with a very gentle heat. An acid phlegm will come over, and be followed by a liquor which at firſt will look like an Oil, but will ſoon congeal in the receiver, and have the appearance of a butter or greaſe. Continue the diſtillation, increaſing the fire by inſenſible degrees, till nothing more will come off. Then ſeparate the butter from the acid phlegm in the receiver, mix it with freſh ſand, and diſtill it again juſt as you did the Wax before. Some acid phlegm will ſtill come off, and an Oil will aſcend, which will not fix in the receiver, though it be ſtill thick. Continue the diſtillation, with a fire ſo governed that the drops may ſucceed each other at the diſtance of ſix or ſeven ſeconds of time. Do not increaſe it, till you perceive the drops fall more ſlowly; and then increaſe it no more than is neceſſary to make the drops follow each other as above directed. When the diſtillation is finiſhed, you will find in the receiver the Oil come wholly over, and a little acid phlegm. Separate the Oil from this liquor; and, if you deſire to have it more fluid, rediſtill it a third time in the ſame manner.

OBSERVATIONS.

BEES-Wax, like all other oily matters in a concrete form, is an Oil thickened by an Acid. Its decompoſition furniſhes us with a very convincing proof of this truth; which, you ſee, is confirmed more and more, by every new analyſis we make of ſuch ſubſtances.

Wax doth not part with all its Acid in the firſt diſtillation: and this is the reaſon that it doth not then become a fluid oil, but a butter, which hath only a degree of ſoftneſs proportioned to the quantity of Acid ſeparated from it. The ſame thing holds with regard to its butter; which loſing, by a ſecond diſtillation, a great part of the remaining Acid which cauſed its conſiſtence, is by that means turned to an Oil. Laſtly, this Oil, from being thick, becomes very fluid by a third diſtillation, and ſo follows the general rule of Oils; which always become the more fluid the oftener they are diſtilled or rectified.

What is here ſaid concerning Wax is applicable to Reſins alſo; which it further reſembles in its conſiſtence and refuſing to diſſolve in water: yet it differs from them eſſentially in ſeveral reſpects; and for this reaſon we thought proper to treat of it in particular. The properties in which it differs from Reſins are theſe:

Firſt, it hath no aromatic ſcent, nor acrid taſte, as Reſins have.

Secondly, it doth not yield a thin limpid Oil in the firſt diſtillation, as they do.

Thirdly, its Oil, or its butter, doth not grow ſenſibly thicker with age. Mr. *Boerhaave* kept ſome butter of Bees-Wax for twenty years, in a veſſel that was not ſtopt, but only covered with a bit of paper; yet it did not grow hard. An Eſſential Oil, though kept much cloſer ſhut up, would in much leſs time have acquired the conſiſtence of a Balſam; and a Balſam, in that time, would have become a Reſin.

Fourthly, Bee's-Wax is not ſoluble in Spirit of Wine; whereas it is the very nature of Reſins to diſſolve in that menſtruum.

Fifthly, I have obſerved that Spirit of Wine acts faintly on the butter of Bee's-Wax; diſſolves that butter when diſtilled to an Oil; unites ſtill more readily with that Oil when rectified by a third diſtillation; and diſſolves it ſtill the more readily the oftener it is diſtilled. Reſins, on the contrary, are more ſoluble in Spirit of Wine than the thin Oils drawn from them; and thoſe Oils acquire the property of reſiſting that menſtruum more and more obſtinately the oftener they are rectified.

By theſe differences we may judge whether it be proper to confound Bee's-Wax with Reſins, or whether it ought not rather to be conſidered as an oily compound of a ſingular ſpecies, which deſerves to be ranked in a different claſs, or at leaſt in ſome other diviſion.

If we take the moſt curſory view of the properties of Eſſential Oils, and compare them with thoſe of Fat Oils, we cannot avoid being ſtruck with a reſemblance between the properties of Eſſential Oils and thoſe of Reſins, as well as with the apparent conformity between the properties of Fat Oils and thoſe of Bee's-Wax: from all which we may conclude with good reaſon, in my opinion, that the Oil of Bee's-Wax is not of the ſame nature with that of Reſins. The Oil of Reſins hath all the properties of an Eſſential Oil, and is juſtly allowed to be an Eſſential Oil rendered thick and ponderous by an Acid. The Oil of Bee's-Wax, on the contrary, hath all the properties of Fat Oils; and there is great room to think that this ſubſtance is really no other than a Fat Oil hardened by an Acid.

Bee's-Wax is not the only oily compound that appears to have a Fat Oil for its baſis. Certain ſhrubs in America yield, by decoction, a ſubſtance that hath all the properties of Bee's-Wax, differing therefrom only in its colour, which is green. The Butter of Cacao is alſo a ſubſtance analogous to Bee's-Wax, and would be really Wax, if it were but as hard; for it contains the ſame principles, but in different proportions: in ſhort, it is to Bee's-Wax what Balſams are to Reſins.

PROCESS V.

The Saccharine Juices of Plants analyſed: inſtanced in Honey.

PUT into a ſtone cucurbite the Honey you intend to diſtill; ſet it in a moderate ſand-heat, and evaporate the greateſt part of its humidity, till you perceive the phlegm begin to be acid. Then take out the matter remaining in the cucurbite, put it into a retort, leaving a full third thereof empty, and diſtill in a reverberatory with degrees of fire. An acid, amber-coloured liquor will come over. As the operation advances this liquor will continually become deeper coloured and more acid, and at the ſame time a little black Oil will aſcend. When the diſtillation is over, you will find in the retort a pretty large charred maſs, which being burnt in the open air, and lixiviated, affords a Fixed Alkali.

OBSERVATIONS.

IF we conſider nothing but the nature of the principles obtained from Honey, we may be induced to think that this ſubſtance is of the ſame kind with Reſins; for we get from each a Phlegm, an Acid, an Oil, and a Coal. Yet there is a very great difference between theſe two ſorts of compounds. Oily matters of the reſinous kind are very inflammable, and by no means ſoluble in water: Honey, on the contrary, is not inflammable in its natural ſtate; will not flame till it be half-conſumed, or turned almoſt to a coal, by the fire; and mixes readily and perfectly with water. Now whence can this difference ariſe? Since it is not owing to the nature of the principles that conſtitute theſe mixts, it muſt neceſſarily be attributed to the proportions in which thoſe principles are united. And indeed, if we attend to the quantities obtained from each by analyzing them ſeverally, we ſhall find that, in this reſpect, there is a very great difference between them. Oily compounds of the nature of Reſins, which are not ſoluble in water, yield in diſtillation a little phlegm, a quantity of Oil vaſtly exceeding that of their Acid, and a very ſmall matter of coal, which, when burnt, ſcarce leaves any token of a Fixed Alkali. Honey, on the contrary, and all other juices of the ſame nature, give out, when analyzed, a great deal of phlegm, a quantity of Acid much ſuperiour to that of their Oil, and a conſiderable maſs of coal; from which, when burnt in the open air and lixiviated, a very perceptible Alkali may be obtained.

If the quantity of the principles procured by theſe two analyſes be compared together, it will be eaſy to deduce from thence the cauſes of the different properties obſerved in the mixts that afforded them. In the large quantity of Oil, of which reſinous ſubſtances conſiſt almoſt entirely, we ſee the cauſe of their being ſo inflammable, and ſo indiſſoluble in water. When ſuch bodies are decompoſed, there remains but little coal, and very little Fixed Alkali; becauſe their Oil carries off with it almoſt all their Acid, leaving a ſcarce perceptible portion thereof fixed in the coal. Now we know that this Acid is an eſſential requiſite to the formation of an Alkali. Honey, on the contrary, and the analogous mixts, are ſo unapt to take fire, and mix ſo readily with water, only becauſe there is very little Oil in their compoſition, in compariſon of the Acid, which is their predominant principle. For the ſame reaſon they leave, when decompoſed, a greater quantity of coal, which alſo yields much more Fixed Alkali than we find in the coals of Reſins. Perhaps theſe mixts may alſo contain a little more earth. The cauſe of this greater quantity of Fixed Alkali will be found in what we delivered above concerning the combination and production of that Salt.

Sugar, Manna, and the Saccharine juices of fruits and plants, are of the ſame nature as Honey, yield the ſame principles, and in the ſame proportions. All theſe ſubſtances muſt be conſidered as Native Soaps; becauſe they conſiſt of an Oil rendered miſcible with water, by means of a ſaline ſubſtance. They differ from the common Artificial Soaps in ſeveral reſpects; but chiefly in this, that their ſaline part is an Acid, whereas that of common Soap is an Alkali. The natural Soaps are not for that reaſon the leſs perfect: on the contrary, they diſſolve in water without deſtroying its tranſparency, and without giving it a milky colour; which proves that Acids are not leſs proper than Alkalis, or rather that they are more proper additaments, for bringing Oils into a ſaponaceous ſtate.

But it muſt be owned that we are not yet able to imitate by art the Acid Soaps which are prepared and ſo perfectly combined by nature, and that the deterſive quality of theſe is not near ſo ſtrong as that of the Soaps which have an Alkali for their ſaline principle.

Though Honey, and the other vegetable ſubſtances analogous to it, contain much Acid, yet they have no taſte of ſourneſs, nor any of the other properties of Acids; but on the contrary their taſte is ſoft and ſaccharine: the cauſe of this is that their Acid is intimately mixed and perfectly combined with their Oil, which entirely ſheathes and blunts it.

PROCESS V.

Gummy Subſtances analyzed: inſtanced in Gum Arabic.

DISTILL Gum Arabic in a retort with degrees of fire. A limpid, ſcentleſs, and taſteleſs phlegm will firſt come over; and then a ruſſet-coloured acid liquor, a little Volatile Alkali, and an Oil, which will firſt be thin and afterwards grow thick. In the retort will be left a good deal of a charred ſubſtance, which being burnt and lixiviated will give a Fixed Alkali.

OBSERVATIONS.

GUMS have at firſt ſight ſome reſemblance of Reſins; which hath occaſioned many reſinous matters to be called Gums, though very improperly: for they are two diſtinct ſorts of ſubſtances, of natures abſolutely different from each other. It hath been ſhewn that Reſins have an aromatic odour; that they are indiſſoluble in water, and ſoluble in Spirit of Wine; that they are only an Eſſential Oil grown thick. Gums, on the contrary, have no odour, are ſoluble in water, indiſſoluble in Spirit of Wine, and, by being analyzed as in the proceſs, are converted almoſt wholly into a phlegm and an Acid. The ſmall portion of Oil contained in them is ſo thoroughly united with their Acid, that it diſſolves perfectly in water, and the ſolution is clear and limpid. In this reſpect Gums reſemble Honey, and the other vegetable juices analogous to it. They are all fluid originally; that is, when they begin to ooze out of their trees. At that time they perfectly reſemble mucilages, or rather they are actual mucilages, which grow thick and hard in time by the evaporation of a great part of their moiſture: juſt as Reſins are true Oils, which, loſing their moſt fluid parts by evaporation, at laſt become ſolid. Infuſions or ſlight decoctions of mucilaginous plants, when evaporated to dryneſs, become actual Gums.

Some trees abound both in Oil and in mucilage: theſe two ſubſtances often mix and flow from the tree blended together. Thus they both grow dry and hard together in one maſs, which of courſe is at the ſame time both gummy and reſinous: and accordingly ſuch mixts are named Gum-Reſins.

But it muſt be obſerved that theſe reſinous and gummy parts ſuffer no alteration by being thus mixed; but each preſerves its properties as if it were alone. The reaſon is that they are not truly united together: Gums being indiſſoluble by Oils or by Reſins, the parts of each are only entangled among thoſe of the other by means of their viſcoſity. Hence, if a Gum-Reſin be put into water, the water will diſſolve only the gummy part without touching the reſinous. On the contrary, if the ſame Gum-Reſin be put into Spirit of Wine, this menſtruum will diſſolve the Reſin and leave the Gum. We ſhall treat more particularly of this diſſolution under the head of Spirit of Wine.

If a Gum-Reſin, inſtead of being only infuſed in water, be triturated with water, it will be thereby wholly diffuſed through it: but the reſinous part, which is only divided by the triture, and not diſſolved in the water, gives the liquor a milky colour, like that of an emulſion. It is indeed an actual emulſion; that which is made with kernels being, like this, no other than a divided Oil, diſperſed in ſmall particles by triture, and ſuſpended in the water by means of a mucilage.

SECTION II.

Of Operations on Fermented Vegetable Subſtances.

CHAP. I.

OF THE PRODUCT OF SPIRITUOUS FERMENTATION.

PROCESS I.

To make Wine of Vegetable Subſtances that are ſuſceptible of Spirituous Fermentation.

LET a liquor ſuſceptible of, and prepared for, the Spirituous Fermentation be put into a caſk. Set this caſk in a temperately warm cellar, and cover the bung-hole with a bit of linen cloth only. In more or leſs time, according to the nature of the liquor to be fermented, and to the degree of heat in the air, the liquor will begin to ſwell, and be rarefied. There will ariſe an inteſtine motion, attended with a ſmall hiſſing and effervеſcence, throwing up bubbles to the ſurface, and diſcharging vapours; while the groſs, viſcous, and thick parts, being driven up by the fermenting motion, and rendered lighter by little bubbles of air adhering to them, will riſe to the top, and there form a kind of ſoft ſpungy cruſt, which will cover the liquor all over. The fermenting motion ſtill continuing, this cruſt will, from time to time, be lifted up and cracked by vapours making their eſcape through it; but thoſe fiſſures will preſently cloſe again, till, the fermentation gradually going off, and at laſt entirely ceaſing, the cruſt will fall in pieces to the bottom of the liquor, which will inſenſibly grow clear. Then ſtop the caſk cloſe with its bung, and ſet it in a cooler place.

OBSERVATIONS.

MATTERS that are ſuſceptible of the Spirituous Fermentation are ſeldom ſo perfectly prepared for it by nature as they require to be. If we except the juices that flow naturally from certain trees, but oftener from inciſions made on purpoſe in them, all other ſubſtances require ſome previous preparation.

Boerhaave, who hath handled this ſubject excellently well in his Chymiſtry, divides the ſubſtances that are fit for Spirituous Fermentation into five claſſes. In the firſt he places all the mealy ſeeds, the legumens, and the kernels of almoſt all fruits. The ſecond claſs includes the juices of all fruits that do not tend to putrefaction. In the third claſs ſtand the juices of all the parts of plants which tend rather to Acidity than to putrefaction; and conſequently thoſe which yield much Volatile Alkali are to be excluded. The fourth claſs comprehends the juices or ſaps that ſpontaneouſly diſtill from ſeveral trees and plants, or flow from them when wounded. He forms his fifth and laſt claſs of the ſaponaceous, ſaccharine, and concrete or thick juices of vegetables. Reſinous or purely gummy matters are excluded, as not being fermentable.

Theſe five claſſes may be reduced to two; one comprehending all the Juices, and another all the Mealy parts, of vegetables that are ſuſceptible of fermentation. The juices want nothing to fit them for fermentation, but to be expreſſed out of the ſubſtances containing them, and to be diluted with a ſufficient quantity of water. If they be very thick, the beſt way is to add ſo much water as ſhall render the mixed liquor juſt capable of bearing a new-laid egg. With reſpect to farinaceous ſubſtances, as they are almoſt all either oily or mucilaginous, they require a little more management. The method of brewing malt-liquors will furniſh us with examples of ſuch management. It is thus deſcribed by Mr. Boerhaave.

In warm weather the grain is put into large vats, and a conſiderable quantity of rain-water, or very clean river-water, is poured thereon, in which it lies till it be well ſoaked and ſwelled. This firſt operation is called the *Steeping*.

When the grain is by this means grown very plump, it is taken out of the ſteep, and laid on great heaps in an open place, yet not too much expoſed to the wind. In a very little time thoſe heaps grow hot, the grain begins to ſprout, and ſhoot out little buds of leaves and roots. The art of managing this operation properly conſiſts in ſeizing the exact point of time when the germination ſhould be ſtopt: on this in a great meaſure depends the ſucceſs of the buſineſs. For, if the grain be left too long in this hot bed, it may begin to rot, or elſe the leaves and roots, by growing too much, may conſume moſt of the mealy ſubſtance, which, in this caſe, is the only ſubject of fermentation; and, if the germination be checked too ſoon, the advantage expected from it will be loſt; that is, the mucid matters will not be ſufficiently attenuated.

As ſoon therefore as the germination is obſerved to have attained its proper ſtage, it muſt be ſtopt with all poſſible expedition. For this purpoſe the grain is carried into an open place expoſed to the north wind, where it is ſpread on a boarded floor and dried; by which means it is hindered from ſprouting any more. It is next made to run ſlowly down through a long tunnel made very hot, which at once dries it thoroughly to the very heart, and in ſome meaſure ſcorches it, though very ſlightly. Grain thus prepared is called *Malt*.

By this germination, exſiccation, and ſlight torrefaction of the grain, the farinaceous ſubſtance is conſiderably attenuated, and its natural viſcoſity deſtroyed, which would otherwiſe hinder the meal when boiled in water from mixing with it and diſſolving in it, as it muſt in ſome meaſure do to form a liquor fit for Spirituous Fermentation.

Mr. Boerhaave takes notice that if grain, which hath not been thus prepared, be chewed in the mouth, its meal makes a paſte that is not eaſily attenuated or entirely diſſolved by the ſpittle; whereas the meal of the ſame grain, after malting, mixes immediately and perfectly with the ſpittle: it hath moreover a ſweet agreable taſte, which common grain hath not.

The grain being thus malted is ground: then hot water is poured thereon, on which it is left to infuſe for three or four hours. In that time the water takes up all the attenuated flour of the Malt; whereas it would not diſſolve the farina of grain that had not undergone the above deſcribed preparations. The Wort is then drawn off the grains, and boiled to a proper degree of inſpiſſation; the decoction is ſuffered to cool, and afterwards put into caſks to be fermented as the proceſs directs.

As Malt-liquor is apt to grow ſour, and will not keep ſo long as Wine, ſome bitter plants are uſually boiled in the decoction, to make it keep the longer, and hinder it from turning ſour ſo ſoon as it otherwiſe would. For this purpoſe ſuch plants are choſen as have an agreably bitter taſte; and the preference is generally given to Hops.

Beſides theſe preparations, relating chiefly to Malt-liquors, there are many other things to be obſerved relating to Spirituous Fermentation in general, and to all matters ſuſceptible of that fermentation. For example; all grains and fruits deſigned for that fermentation muſt be perfectly ripe; for otherways they will not ferment without difficulty, and will produce little or no inflammable Spirit. Such matters as are too auſtere, too acrid, or aſtringent, are for the ſame reaſon unfit for Spirituous Fermentation; as well as thoſe which abound too much in Oil.

In order to make the fermentation ſucceed perfectly, ſo as to produce the beſt Wine that the fermented liquor is capable of affording, it is neceſſary to let it ſtand quiet without ſtirring it, leſt the cruſt that forms on its ſurface ſhould be broken to little fragments, and mix with the liquor. This cruſt is a kind of cover, which hinders the ſpirituous parts from exhaling as faſt as they are formed. The free acceſs of the air is another condition neceſſary to fermentation: and for this reaſon the veſſel that contains the fermenting liquor muſt not be cloſe ſtopped; the bung-hole is only to be covered with a linnen cloth, to hinder dirt and inſects from falling into it. Nor muſt the bung-hole be too large, leſt too much of the ſpirituous parts ſhould eſcape and be loſt.

Laſtly, a juſt degree of warmth is one of the conditions moſt neceſſary for fermentation: for in very cold weather there is no fermentation at all; and too much heat precipitates it in ſuch a manner that the whole liquor becomes turbid, and many fermenting and fermented particles are diſſipated.

If, notwithſtanding the exacteſt obſervance of every particular requiſite to excite a ſucceſsful fermentation, the liquor cannot, without difficulty, be brought to effervefce, which ſcarce ever happens but to Malt-liquor, it may be accelerated by mixing therewith ſome matter that is very ſuſceptible of fermentation, or actually fermenting. Such matters are called *Ferments.* The cruſt that forms on the ſurface of fermenting liquors is a moſt efficacious ferment, and on that account very much uſed.

It ſometimes happens that there is occaſion to check the fermentation excited in the liquor, before it ceaſes of itſelf. To effect this, ſuch means muſt be uſed as are directly oppoſite to thoſe mentioned above for promoting fermentation. The ſame end is obtained by mixing with the liquor a quantity of Alkali, ſufficient to abſorb the Acid contained therein: but this method is ſeldom made uſe of, becauſe it ſpoils the liquor; which, after being thus treated, is incapable of any ſpirituous fermentation, but on the contrary will certainly putrefy.

Spirituous fermentation may alſo be ſtopped by mixing with the liquor a great quantity of ſome mineral Acid. But this likewiſe alters its nature; becauſe theſe Acids, being fixed, always remain confounded therewith, and never ſeparate from it.

The beſt method yet found out for checking this fermentation, without injury to the fermenting liquor, is to impregnate it with the fumes of burning ſulphur. Theſe fumes are known to be acid, and it is that quality in them which ſuſpends the fermentation. But at the ſame time this Acid is extremely volatile; ſo that it ſeparates ſpontaneouſly from the liquor, after ſome time, and leaves it in a condition to continue its fermentation.

For this reaſon when a Wine is deſired that ſhall be but half fermented, and ſhall partly retain the ſweet taſte it had in the ſtate of *Muſt*, (the proper name for the unfermented juice of the grape,) it is put into caſks in which Sulphur hath been previouſly burnt, and the vapours thereof confined by ſtopping the bung-hole. Theſe are called *Matched Wines*. If the ſame operation be performed on Muſt, its fermentation will be abſolutely prevented: it will retain all its ſaccharine taſte, and is then called *Stum*. As the ſulphureous Acid evaporates ſpontaneouſly, in no long ſpace, it is neceſſary to fumigate matched wines or ſtums from time to time, when they are intended to be kept long without fermenting.

PROCESS II.

To draw an Ardent Spirit from ſubſtances that have undergone the Spirituous Fermentation. The analyſis of Wine.

FILL a large copper cucurbite half full of Wine. Fit on its head and refrigeratory. Lute on a receiver with wet bladder, and diſtill with a gentle fire; yet ſo that the drops which fall from the noſe of the Alembic may ſucceed one another pretty quick, and form a ſort of ſmall continued ſtream. Go on thus till you perceive that the liquor which comes over ceaſes to be inflammable; and then deſiſt. You will find in the receiver a clear liquor, ſomewhat inclining to an amber-colour, of a pleaſant quick ſmell, and which being thrown into the fire inſtantly flames. The quantity thereof will be nearly a fourth part of the Wine you put into the alembic; and this is what is called *Brandy*; that is, the Ardent Spirit of Wine loaded with much phlegm.

In order to rectify it, and reduce it to Spirit of Wine, put it into a long-necked matraſs, capable of holding double the quantity. Fit a head to the matraſs, and lute on a receiver: place your matraſs over a pot half-full of water; ſet this pot over a moderate fire; and with this vapour-bath diſtill your Spirit, which will riſe pure. Continue this degree of heat till nothing more will come over. You will find in the receiver a very clear colourleſs Spirit of Wine, of a quick but agreeable ſmell, which will catch fire at once by the bare contact of any flaming ſubſtance.

OBSERVATIONS.

IT hath been ſhewn that Honey, and the vegetable juices analogous to it, ſuch as Muſt, and the juices of all ſaccharine fruits and plants, yield by diſtillation no other principles than phlegm, an Acid, and a ſmall quantity of Oil. The analyſis of Wine, and of all ſubſtances that have undergone the ſpirituous fermentation, ſhews us that this fermentation produces, and in ſome ſenſe creates, in thoſe mixts, a principle that did not exiſt in them before; I mean the Ardent Spirit, which is an inflammable liquor that is miſcible with water. This liquor reſults from a cloſer combination of the Acid and the Oil, which are attenuated and united together by fermentation. To this Oil, which is one of its conſtituent parts, its inflammability is owing; and the Acid imparts to this Oil the property of mixing with water, more perfectly and more intimately than when it makes a part of any other compound. Nay, there is, in the very compoſition of an Ardent Spirit, a certain quantity of water which is neceſſary to it, which is one of its eſſential parts, and without which it would not have the properties that characteriſe it. We ſhall preſently have occaſion to ſee, that, when Spirit of Wine is dephlegmated to a certain pitch, we cannot deprive it of any more of its aqueous parts, without decompoſing a quantity of the Spirit proportioned to the quantity of water drawn from it.

Ardent Spirits are more volatile than any of the principles of the mixt from which they are produced, and conſequently more volatile than the phlegm, the Acid, or the Oil thereof, though they wholly conſiſt of theſe. This cannot be attributed to any thing but a peculiar diſpoſition of theſe principles, which are attenuated in a ſingular manner by the fermenting motion, and thereby rendered more ſuſceptible of expanſion and rarefaction.

The great volatility of the Ardent Spirit procures us an eaſy method of ſeparating it from the other principles of Wine, and of dephlegmating it. For this purpoſe it need only be diſtilled with ſuch a gentle heat as is juſt capable of raiſing the Spirit, but too weak to produce the ſame effect on the other matters from which you deſire to free it. For this reaſon the more ſlowly, and with the leſs heat, you diſtill your Wine, the ſtronger and more ſpirituous will your Brandy be. The ſame is to be ſaid of the ſecond diſtillation, by which Brandy is changed into Spirit of Wine, or, in other words, dephlegmated. The Spirit of Wine thus drawn from it will be ſo much the better, the more exactly you obſerve the conditions here propoſed.

If Spirit of Wine be treated in the ſame manner as Brandy, that is, if it be rectified by diſtillation with the ſame precautions, it will be thereby dephlegmated as much as poſſible; and then it is called *Alkohol.* By this rectification it is not only freed from its redundant phlegm, but alſo from ſome particles of Acid and of Oil, which, though much leſs volatile than itſelf, yet aſcend with it in the firſt diſtillation: nor is it poſſible wholly to avoid this inconvenience.

Mr. Boerhaave propoſes to dephlegmate Spirit of Wine more eaſily, and more accurately, by diſtilling it from decrepitated Sea-ſalt mixed, while very hot, with the Spirit. This muſt certainly be a very good method; becauſe decrepitated Sea-ſalt powerfully attracts moiſture, and conſequently is very apt to imbibe and retain that which is in the Ardent Spirit: and Spirit of Wine doth not diſſolve Sea-ſalt; ſo that there is no reaſon to fear its being in the leaſt contaminated therewith.

All fermented liquors do not yield near an equal quantity of Ardent Spirit; becauſe they do not all, before fermentation, equally contain the principles neceſſary to produce an Ardent Spirit, in the moſt advantageous proportion or diſpoſition.

There are ſeveral ways of proving whether or no Spirit of Wine be as highly rectified as it poſſibly can be, that is, whether or no it contains any more phlegm than is preciſely neceſſary to conſtitute it Spirit of Wine; and many Chymiſts have judged that to deſerve the title which burns away entirely, without leaving behind it the leaſt token of humidity; or that which, being burnt on gun-powder, fires it at laſt.

But Mr. Boerhaave juſtly obſerves that neither of theſe is a ſufficient proof; becauſe, though there ſhould be a ſmall quantity of unneceſſary phlegm in Spirit of Wine, yet it may very well be evaporated and diſſipated by the deflagration in either way. He therefore propoſes another proof, which is much more to be depended on; that is, by mixing and ſhaking with the Spirit of Wine a ſmall quantity of a very dry pulverized Alkali. If this Salt, when thus agitated, and even warmed, with Spirit of Wine, continue as dry as it was at firſt, it is a ſign that the Spirit is perfectly dephlegmated.

Mr. Boerhaave tried in this manner ſome Spirit of Wine that had fired gun-powder, and found it to contain ſo much phlegm that it moiſtened his Salt very perceptibly: nay, one ſingle drop of water, being mixed with a conſiderable quantity of Spirit of Wine, which before left the Alkali perfectly dry, diſcovered itſelf in this way by the moiſture it communicated to the very ſame Salt.

Spirit of Wine may alſo be contaminated with ſome heterogeneous ſubſtances; ſuch as acid, alkaline, or oily matters. Theſe are to be diſcovered by very eaſy experiments proper to each: for an acid or alkalious Spirit of Wine being mixed with ſyrup of violets will give it a red or a green colour, according to the nature of the ſaline matter contained in it; and, if it be combined with an Oil, that will ſhew itſelf by the white milky colour which a drop of it will give to water.

Beſides the Ardent Spirit, Wine contains an Acid united with a portion of earth and of Oil, which give the Acid a concrete form. This ſubſtance generally ſeparates ſpontaneouſly from the Wine, and adheres, in the form of a ſtrong cruſt, to the ſides of the caſk. It is called *Tartar*, and is, properly ſpeaking, the Eſſential Salt of Wine. We ſhall exhibite the analyſis of Tartar, and treat of it more at length, in a Chapter apart.

Wine-lees conſiſt of the groſſeſt parts of the fermented liquor; which being uncapable of remaining diſſolved, ſink to the bottom and form a ſediment, which contains alſo ſome Tartar and a little Ardent Spirit.

The reſidue left in the cucurbite, after the Spirit is drawn off, is a ſort of Extract of Wine. This liquor hath an exceeding rough, or rather acid taſte. When diſtilled it yields an acid phlegm, which comes more and more acid as the diſtillation advances, and a fetid empyreumatic Oil. From the *caput* *mortuum*, when burnt, a conſiderable quantity of a Fixed Alkali may be extracted.

From all this it follows that Wine conſiſts of an Ardent Spirit, and a Tartarous Acid, diffuſed through a great quantity of water, together with ſome oily and earthy parts.

Malt-liquor contains much leſs Tartar than Wine; but, inſtead thereof, it is impregnated with a mucilaginous matter, which becomes very perceptible when any body is ſmeared with it and dried; for then it makes a kind of Varniſh. This mucilaginous matter, which is not ſufficiently attenuated, eſpecially when the Malt-liquor is new, makes it very apt to ſwell up and riſe over the helm with rapidity, in the diſtillation of an Ardent Spirit from it: for which reaſon it is neceſſary to proceed more cautiouſly and more ſlowly in diſtilling a Spirit from this liquor than from Wine.

PROCESS III.

To dephlegmate Spirit of Wine by the means of Fixed Alkalis. Spirit of Wine analyzed.

INTO a glaſs cucurbite pour the Spirit of Wine you intend to dephlegmate, and add to it about a third part of its weight of Fixed Alkali, newly calcined, perfectly dry, heated, and pulverized. Shake the veſſel, that the two matters may be mixed and blended together. The Salt will gradually grow moiſt, and, if the Spirit of Wine be very aqueous, melt into a liquor, that will always ly at the bottom of the veſſel, without uniting with the Spirit of Wine which will ſwim at top.

When you perceive that the Alkali attracts no new moiſture, and that no more of it melts, decant your Spirit of Wine from the liquor beneath it, and add to your Spirit freſh Salt thoroughly dried as before. This Salt alſo will imbibe a little moiſture; but it will not grow liquid, becauſe the Alkali, with which it was mixed before, hath left too little phlegm to melt this. Decant it from this Salt as at firſt, and continue to mix and ſhake it in the ſame manner with freſh Salt, till you obſerve that the Salt remains as dry after as it was before mixing it with the Spirit of Wine. Then diſtill your Spirit in a ſmall alembic with a gentle heat, and you will have it as much dephlegmated as it can be.

OBSERVATIONS.

NEXT to the Mineral Acids, Fixed Alkalis perfectly calcined are the ſubſtances which have the greateſt affinity with water, and therefore it is no wonder they are ſo very fit to dephlegmate Spirit of Wine, and to free it from all its redundant humidity. Indeed Spirit of Wine cannot be perfectly dephlegmated without their aſſiſtance: for when diſtillation alone is made uſe of for that purpoſe, it is impoſſible to prevent ſome phlegm from riſing with the Spirit of Wine, whatever precautions we take to avoid it. Hence it comes to paſs that Spirit of Wine, though ever ſo highly rectified by diſtillation, always imparts a little moiſture to an Alkali, when mixed with it in order to prove its goodneſs.

But, while the Alkali attracts the ſuper-abundant phlegm of the Spirit of Wine, it produces in that liquor, and undergoes itſelf, remarkable changes.

Spirit of Wine, when ſo highly dephlegmated by an Alkali that, being kept in digeſtion therewith, it leaves the Salt perfectly dry, hath a red colour, an odour ſomewhat different from that which is peculiar to it when perfectly pure, a taſte in which that of the Fixed Alkali may be diſtinguiſhed; and it makes a ſlight effervеſcence with Acids: which manifeſtly proves that it is united with a portion of the Alkali employed to rectify it.

Mr. Boerhaave thinks, with great probability, that this portion of the Alkali unites with the Spirit of Wine, much in the ſame manner as with Oils, viz. that it forms with the Spirit a kind of liquid Soap. He obſerves that this alkalizated Spirit cleans the fingers; and that things wetted with it do not dry ſo ſpeedily as thoſe wetted with pure Spirit of Wine. This alkalizated Spirit is alſo called *Tincture of Salt of Tartar*.

In making this Alkaline Tincture, great care is to be taken that the Spirit of Wine you uſe be as highly rectified as poſſible: for, as long as it communicates any phlegm to the Alkali, it doth not acquire from the Salt mixed with it either the red colour, or the other properties which ſhew it to have diſſolved part thereof. It is alſo a rule to throw the Alkali exceeding hot into the Spirit of Wine, which being heated before hand boils on the addition of the hot Salt. In order to render the Tincture ſtill ſtronger, they are left to digeſt together for ſome time; after which, if part of the Spirit of Wine be drawn off by diſtillation, the remainder will have a redder colour and a more acrid taſte.

The Spirit drawn off by diſtillation is clear, colourleſs, and doth not give the ſame tokens of an Alkaline quality as the Tincture; and for that reaſon, as the deſign of the preſent proceſs is only to dephlegmate and rectify Spirit of Wine by means of a Fixed Alkali, we have directed it to be diſtilled as ſoon as all its phlegm is abſorbed by the Salt.

However, Spirit of Wine rectified in this manner muſt not be conſidered as abſolutely pure; for a ſmall degree of an Alkaline reliſh is ſtill perceptible in it: but that doth not hinder its being employed with ſucceſs in ſeveral Chymical operations, where the quality chiefly required in Spirit of Wine is that it be perfectly dephlegmated.

In order to free Spirit of Wine from the ſmall portion of Alkali remaining in it after diſtillation, Mr. Boerhaave propoſes to mix with it a few drops of the Vitriolic Acid, before the laſt diſtillation. But there is great reaſon to apprehend an oppoſite inconvenience from this practice: that is, inſtead of an Alkaline character, we may give the Spirit an Acid taint. Indeed this cannot be avoided, but by mixing with the Spirit of Wine exactly as much Acid, as ſuffices to ſaturate the Alkali contained in it, and no more; which is a point very difficult to hit.

Van Helmont tells us that having diſtilled Spirit of Wine from Salt of Tartar perfectly calcined, half of it came over pure water; and Mr. Boerhaave, to whom this appeared very ſurpriſing, reſolved to repeat Van Helmont's experiment, in order to ſatisfy himſelf of the truth, and ſee with his own eyes what would be the reſult. With this view he made a tincture of Salt of Tartar in the manner above deſcribed, as ſtrong and as fully impregnated as he poſſibly could. He ſet it in digeſtion with the Alkali for ſeveral months, and afterwards let it ſtand four years without touching it. He then poured the whole into a cucurbite, and drew off the Spirit of Wine from the Salt by diſtillation. The Spirit of Wine, which was before very red, became clear on being diſtilled, having left its colour in the Salt which remained at the bottom of the cucurbite. This Spirit he returned upon the Salt, and diſtilled as before. He obſerved, that, in this ſecond diſtillation, the Spirit of Wine roſe with a little more difficulty, and that the remaining Salt was of a more ſaturated colour, and become of a dark red. In this manner he cohobated and diſtilled his Spirit twenty times, with the ſame Salt. He then found that the Spirit of Wine had acquired a cauſtic, fiery taſte, and that the ſaline maſs in the bottom of the cucurbite was grown black. This ſaline reſidue he diſtilled with a ſtronger fire, and obtained from it a liquor, which was water, and not Spirit of Wine.

Though Mr. Boerhaave ſeems, by this tedious labour, to have made Van Helmont's experiment ſucceed, at leaſt in part, yet that famous and accurate Philoſopher did not flatter himſelf with the notion of having ſolved the problem. He firſt obſerves that he was far from getting the quantity of water which Van Helmont ſays he obtained, viz. half the weight of the Spirit of Wine. Secondly, he could ſcarce think that the quantity he did obtain actually came from the Spirit of Wine. The thing appeared to him ſo ſingular, and ſo hard to be accounted for, that he inclined to believe the water was quite extraneous both to his Spirit of Wine and to his Salt, and that it came from the air, which could not but be admitted in the frequent cohobations of the Spirit of Wine with the Alkali.

When Mr. Boerhaave undertook this long laborious courſe of operations, he had it alſo in his view to try whether he could not, by the ſame means, ſolve another problem famed among the Chymiſts, namely the Volatilization of the Salt of Tartar. He acquaints us that in this alſo he failed; which may eaſily be believed: but, in my opinion, he was more ſucceſsful, with regard to the firſt point, than he himſelf imagined; for I think the water he obtained came immediately from the Spirit of Wine. We ſhall eaſily be convinced of this, if we carefully conſider all the circumſtances attending his experiments.

It hath been ſhewn that Spirit of Wine conſiſts of an Oil, of an Acid, and of water with which the Oil is intimately mixed by means of the Acid; that

Spirit of Wine, which is not perfectly dephlegmated, may be deprived of a pretty conſiderable quantity of water which is ſuperfluous and unneceſſary to its compoſition; and that it ſuffers no change thereby, except that it becomes lighter, ſtronger, more inflammable, in ſhort, more Spirit of Wine: but that, when it is once freed of this ſuper-abundant phlegm, it would be in vain to attempt ſeparating a greater quantity of water from it. All the water then left in it is eſſential to its compoſition, and neceſſary to give it its properties; for without that it would not be Spirit of Wine, but only an Oil loaded with an Acid.

This being laid down, the water which cannot be ſeparated from Spirit of Wine while it continues Spirit of Wine, muſt become ſenſible when it is decompoſed. And this actually comes to paſs: for if you rob Spirit of Wine of one of its principles, its Oil, for inſtance, and for that purpoſe burn it under a glaſs bell, as you do Sulphur, you will by this means collect a great quantity of water, even though you make uſe of the moſt highly rectified Spirit of Wine; which proves that this water was one of the eſſential parts that conſtituted the Spirit.

If, inſtead of depriving this mixt of its oily principle, you ſeparate from it one of its other principles, ſuch as its Acid. it is plain that it will in like manner be decompoſed, and that then the Oil and the water, which were combined together only by means of that Acid, will ſeparate from one another and appear each in its natural form. Now this is exactly the caſe in Van Helmont's experiment, as repeated by Boerhaave. The Fixed Alkali, on which the Spirit of Wine is cohobated, hath a greater affinity with the Acid of this mixt than with its phlegm or its Oil. It therefore unites with part of that Acid; by which means a proportional quantity of its Oil and water muſt needs ſeparate from each other, and of courſe a portion of the Spirit of Wine will be decompoſed. Accordingly Boerhaave obſerved, that, in dephlegmating Spirit of Wine by a Fixed Alkali, a portion of Oil is always ſeparated from it, and that the Alkali employed in this operation is impregnated with an Acid, ſo that, when it hath been ſeveral times uſed for this purpoſe, it is almoſt changed into a Neutral Salt, and hath acquired the properties of the Foliated Salt of Tartar. That on which Spirit of Wine hath been cohobated a great number of times muſt conſequently be impregnated with a great quantity of Acid; and, as the Acid carries with it a great deal of water, it is not ſurpriſing that when the Alkali, thus impregnated with Acid and phlegm, is expoſed to a ſtrong fire, the phlegm ſhould be ſeparated from it, ſeeing the union between them is but weak.

Thus it appears that the water obtained by Mr. Boerhaave, in his experiment, came immediately from the Spirit of Wine, agreeably to Van Helmont's notion; whoſe moſt intelligent followers have clearly explained his ſentiments on this ſubject, telling us, as their author's poſitive aſſertion, that "in his experiment the pureſt Spirit of Wine depoſites one "of its principles in the Salt of Tartar; that another of them is turned into water, and ſo ſeparated from that Spirit and from the principle "attracted by the Salt of Tartar; that conſequently "Spirit of Wine certainly conſiſts of theſe two "principles, which may be ſeparated from each "other; and that the principle which unites with "the Alkali of the Tartar changes that Salt into "a medicament, or Balſam, of admirable virtue "in curing wounds, known by the title of the "*Samech* of *Paracelſus*."

It may here be aſked why Boerhaave obtained but a ſmall quantity of water in his experiment, ſeeing Van Helmont pretends that it ought to be equal to half the weight of the Spirit of Wine. The moſt natural anſwer to this queſtion is, that, as Van Helmont did not publiſh all the circumſtances of his experiment, there is reaſon to think Boerhaave did not go about it in the ſame manner as Van Helmont did.

In my opinion he would have ſucceeded perfectly, and have obtained from his Spirit of Wine the whole quantity of water he deſired, if, inſtead of cohobating it always on the ſame Alkali, he had taken freſh Alkali every time; had drawn a tincture from it; had diſtilled his Spirit of Wine from this Salt; and, after collecting all the parcels of Alkali remaining after thoſe diſtillations, he had expoſed them to a ſtrong fire, in order to ſeparate all the moiſture contained in them. Perhaps alſo ſuch a great number of cohobations and diſtillations would not have been neceſſary to decompoſe the Spirit of Wine totally by this method; eſpecially if he had employed a greater quantity of Alkali in each operation. For it is evident that a Fixed Alkali, by being impregnated with a certain quantity of the Acid and water of the Spirit of Wine, loſes thereby a great deal of its ſtrength and activity, and at laſt becomes incapable of abſorbing any more; ſo that, when it is entirely ſaturated, it is no more able to act upon Spirit of Wine, ſo as to decompoſe it, than ſo much Vitriolated Tartar or common Sand. Hence you ſee that there are ſtill many beautiful experiments to be made on this ſubject, and that we may hope by a regular courſe of them to obtain a perfect ſolution of Van-Helmont's problem.

In the following proceſſes we ſhall treat of another method of decompoſing Spirit of Wine, which conſiſts in depriving it of its eſſential water, or aqueous principle, by the means of highly concentrated Acids.

CHAP. II.

SPIRIT OF WINE COMBINED WITH DIFFERENT SUBSTANCES.

PROCESS I.

To combine Spirit of Wine with the Vitriolic Acid. This combination decompounded: Rabel's Water. Æther. Sweet Oil of Vitriol. Hoffman's Anodyne Mineral Liquor.

INTO an Engliſh glaſs retort put two pounds of Spirit of Wine perfectly dephlegmated, and pour on it at once two pounds of highly concentrated Oil of Vitriol: ſhake the retort gently ſeveral times, in order to mix the two liquors. This will produce an ebullition, and conſiderable heat; vapours will aſcend, with a pretty loud hiſſing noiſe, which will diffuſe a very aromatic ſmell, and the mixture will be of a deeper or lighter red colour, according as the Spirit of Wine was more or leſs oily. Set the retort on a ſand-bath made nearly as hot as the liquor; lute on a tubulated ballon, and diſtill the mixture with a fire ſtrong enough to keep the liquor always boiling: a very aromatic Spirit of Wine will firſt come over into the ballon, after which the Æther will riſe. When about five or ſix ounces of it are come off, you will ſee in the upper concavity of the retort a vaſt number of little points in a veined form, which will appear fixed, and which are nevertheleſs ſo many little drops of Æther, rolling over one another, and trickling down into the re-

receiver. Theſe little points continue to appear and ſucceed each other to the end of the operation: Keep up the ſame degree of fire, till upon opening the little hole in the ballon you perceive that the vapours, which inſtantly fill the receiver, have the ſuffocating ſmell of Volatile Spirit of Sulphur.*

Then unlute the ballon, pour the liquor it contains into a cryſtal bottle, and ſtop it cloſe: there will be about eighteen ounces of it. Lute on your receiver again, and continue the diſtillation with a greater degree of fire. There will come over an aqueous, acid liquor, ſmelling ſtrong of a ſulphureous ſpirit, which is not inflammable. It will be accompanied with undulating vapours; which being condenſed will form an oil, moſt commonly yellow, one part of which will float on the ſurface of the liquor, and another will ſink to the bottom.

Towards the end of the diſtillation of this acid liquor, and of the yellow Oil of which it is the vehicle, that part of the mixture, which is left in the retort and grown black, will begin to riſe in froth. Then ſuppreſs your fire at once: ſtop the diſtillation and change your receiver once more. When the veſſels are grown pretty cool, finiſh your diſtillation with a lamp-heat kept up for twelve or fifteen days, which in all that time will raiſe but a very little ſulphureous ſpirit. Then break your retort, in which you will find a black, ſolid maſs, like a Bitumen. It will have an acid taſte, ariſing from a remainder of the Acid imperfectly combined with Oil.

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* Theſe white vapours do not appear when the veſſels are perfectly cloſe. Mr. *Hellot*, to whom we owe the remark, having performed this operation in a cryſtal retort procured from *London*, the neck of which had been rubbed with emery in the mouth of its receiver, ſo that theſe two veſſels fitted each other exactly, ſaw the æthereal liquor diſtill pretty faſt, but without white vapours. He then looſened the receiver, by turning it a little upon the neck of the retort, ſo that the external air might get in; whereupon the white vapours appeared immediately. When the receiver was cloſe fitted on again, the vapours diſappeared. He repeated the ſame thing five times from half hour to half hour, and theſe vapours as often appeared and diſappeared.

This artificial Bitumen may be freed from its redundant Acid, by waſhing it in ſeveral waters. Then put it into a glaſs retort, and diſtill it with a ſtrong reverberated fire. You will obtain a rediſh Oil that will ſwim on water, much like the Oil obtained by diſtilling the natural Bitumens. This Oil alſo will be accompanied with an aqueous acid liquor. In the retort will be left a charred matter, which, being put into an ignited crucible in the fire, burns for ſome time, and, when well calcined, leaves a white earth.

The liquors that riſe firſt in this diſtillation, and which we directed to be kept by themſelves, are a mixture conſiſting 1. of a highly dephlegmated Spirit of Wine, of a moſt fragrant ſmell; 2. of Æther, which the Spirit of Wine wherewith it is united renders miſcible with water; 3. of a portion of Oil, which commonly riſes with the Æther towards the end of the operation; 4. and ſometimes of a little Sulphureous Acid, if the receiver be not changed ſoon enough.

In order to ſeparate the Æther from theſe other ſubſtances, put the whole into an Engliſh retort, with a little Oil of Tartar *per deliquium* to abſorb the Sulphureous Acid, and diſtill very ſlowly in a ſand-bath heated by a lamp, till near half the liquor be come over. Then ceaſe diſtilling; put the liquor in the receiver into a phial with ſome water, and ſhake it; you will ſee it riſe with rapidity to the upper part of the phial, and float on the ſurface of the water: this is the Æther.

OBSERVATIONS.

THIS operation is only a decompoſition of Spirit of Wine by means of Oil of Vitriol. In the preceding proceſs we ſaw that this Spirit, which conſiſts of three eſſential principles, viz. an Oil, an Acid, and Water, cannot be deprived of one of them without being at the ſame time decompoſed; the two others that remain having, by ſuch ſeparation, loſt the bond of intimate union and connection that was between them. We ſaw alſo that Spirit of Wine, when mixed and digeſted with a very cauſtic Fixed Alkali, and ſeveral times diſtilled from it, depoſites its Acid in that Salt: and hence it comes that the Oil and the Water, being deprived of the principle which was the bond of their union, ſeparate from each other, and appear in their natural forms.

In the preſent experiment the Vitriolic Acid decompoſes the Spirit of Wine in a different manner. We know that this Acid acts powerfully on Oils; and that, when it is highly concentrated, as the operation requires it ſhould be, it ſeizes and attracts with ſurpriſing force the moiſture of all bodies that touch it. So that, when it is mixed with Spirit of Wine, it acts at the ſame time both on the aqueous and on the oily principle of that mixt. The rapidity and activity, wherewith it ruſhes into union with theſe ſubſtances, produce the heat, the ebullition, and the hiſſing noiſe, which we obſerve during the firſt moments after their mixture.

The red colour, which the two liquors confounded together acquire after ſome time, is owing to the combination of the acid with the oily part: for it is known that Oils as colourleſs as Spirit of Wine, ſuch as the Eſſential Oil of Turpentine, become of a browniſh red when diſſolved by a concentrated Acid: and Kunckel obſerved, that, the more Oil there is in Spirit of Wine mixed with Oil of Vitriol, the deeper is the red colour it acquires on being ſo mixed. He even gives this experiment as the certain means of diſcovering whether Spirit of Wine be more or leſs oily; and he adds, that Spirit of Wine, which hath loſt part of its Oil by being rectified with Lime, acquires leſs redneſs than any other by being mixed with Oil of Vitriol.

When the mixture hath acquired this colour, and before it undergoes diſtillation, it appears like a homogeneous liquor. There is as yet no decompoſition; or at leaſt none that is perceptible; and the Vitriolic Acid is united at the ſame time with the Oil, the Acid, and the Water of the Spirit of Wine; that is, with the whole Spirit of Wine in ſubſtance. This mixture, when made with three parts of Spirit of Wine to one of Oil of Vitriol, is an aſtringent remedy much uſed in hemorrhages, and known by the name of *Rabel's Water*.

The actual decompoſition of the Spirit of Wine is effected by the diſtillation. The firſt liquor, or the firſt portion of the liquor that riſes before the reſt, hath the ſmell and all the properties of Spirit of Wine. It is indeed part of the Spirit of Wine employed as an ingredient in the mixture; but, being abſtracted from a highly concentrated Oil of Vitriol, which, of all known ſubſtances, attracts moiſture with the greateſt power, it is perfectly freed of all its unneceſſary phlegm, and retains no more than what is a conſtituent part thereof, as one of its principles, without which it would not be Spirit of Wine.

The liquor that ſucceeds this firſt Spirit of Wine is of a different nature. It may be conſidered as an Æther: for, though it be not a pure Æther, it contains the whole of it: from this liquor only can it be obtained; it is no other than an Æther mixed with ſome of the Spirit of Wine that comes over firſt, and a little of the acid liquor which comes afterward. Now the production of Æther is the effect of a beginning decompoſition of the Spirit of Wine: it is Spirit of Wine degenerated, half-decompoſed; Spirit of Wine too highly dephlegmated; that is, Spirit of Wine which hath loſt a part of its eſſential phlegm, of that phlegm which as a neceſſary principle made it Spirit of Wine: it is a liquor ſtill compoſed of oily parts mixed with aqueous parts, and on that account muſt retain a reſemblance of Spirit of Wine; but ſuch that its oily parts, not being diſſolved and diffuſed among a ſufficient number of aqueous particles, are brought nearer to each other than they ſhould be to conſtitute perfect Spirit of Wine; on which account it is not now miſcible with water, but is as much nearer to the nature of Oil, as it is removed from the nature of Spirit of Wine: it is a liquor, in ſhort, which, being neither Spirit of Wine nor pure Oil, yet poſſeſſes ſome properties in common with both, and is conſequently to be ranked in the middle between them.

This explanation of the nature of Æther, which I imagine was never before given by any other, is the ſame that we propoſed in our Elements of the Theory of Chymiſtry, which may be conſulted on this occaſion.

An objection againſt this opinion may, perhaps, be drawn from an experiment well known in Chymiſtry. It may be ſaid, that, if Æther were nothing but depraved Spirit of Wine, which ceaſes to be miſcible with water, becauſe the loſs it hath ſuſtained of a portion of the water neceſſary to its conſtitution hath diſordered the proportion which ought to ſubſiſt between its aqueous and oily parts, from which proportion it derives that property, it would be very eaſy to change Spirit of Wine into Æther by a method quite contrary to the uſual one; viz. by mixing Spirit of Wine with a ſufficient quantity of ſuperfluous Oil: for it ſeems to be a matter of indifference whether the proportion, between the aqueous and the oily parts of Spirit of Wine, be changed by leſſening the quantity of the former, as in the common operation for Æther, or by increaſing the quantity of the latter, as is here propoſed;

poſed; and we can, by the laſt method, put theſe two principles together in what proportion we pleaſe. Now it is certain that, whatever quantity of Oil be diſſolved in Spirit of Wine, it will ſtill remain miſcible with water; and that, if Spirit of Wine thus replete with Oil be mixed with water, it will unite therewith as uſual, and quit the Oil which it had diſſolved.

This objection, though ſeemingly a very ſpecious one, will be removed with the utmoſt eaſe, if we reflect but ever ſo little on ſome of the principles already laid down. We ſaid, and we gave ſome inſtances of it, that certain ſubſtances may be united together in ſundry different manners; ſo that from theſe combinations, though made in the ſame proportions, there ſhall reſult compounds of very diſſimilar properties. The combination we are now conſidering is another evidence of this truth. It is allowed that the proportion between the oily and the aqueous parts may be exactly the ſame in Æther and in Spirit of Wine replete with Oil; but it muſt alſo be owned that the manner in which the Oil is combined in theſe two caſes is very different.

That Oil, which at firſt is a conſtituting part of the Spirit of Wine, and afterwards becomes a part of the Æther, is united with the other principles of thoſe mixts, that is, with their Acid and their Water, by the means of fermentation, whereby it is much more attenuated, and much more cloſely combined, than that with which Spirit of Wine is impregnated by diſſolution only. And accordingly this adventitious Oil is ſo ſlightly connected with Spirit of Wine, that it is eaſily ſeparable from it by barely diſtilling it, or even mixing it with water: whereas that which makes a part of Spirit of Wine, as one of its conſtituent principles, is united therewith in ſuch a manner as not to be ſeparable from it by either of theſe methods, nor indeed without employing the moſt vigorous and powerful agents for that purpoſe. So that the chief differences between Æther and Oily Spirit of Wine muſt be aſcribed to the different manner in which the Oil is combined in theſe two mixts: and, if a ſufficient quantity of ſuperfluous Oil could be united with Spirit of Wine, in ſuch a manner that, without being ſoapy, it ſhould not be ſeparable therefrom by the affuſion of water, I make no doubt but ſuch a Spirit of Wine would be perfectly like Æther, ſo far as not to be miſcible with water.

But let us return to our diſtillation, and trace the decompoſition of Spirit of Wine by the Vitriolic Acid. We have ſhewn that the Acid begins with attracting part of the Water which conſtitutes the Spirit of Wine, by which means it changes the nature of this compound, deſtroys its miſcibility with water, and brings it as much nearer to the nature of an Oil as it thereby removes it from the nature of Spirit of Wine.

According to the theory laid down it is evident, that, if the Acid continue to act in the ſame manner on Spirit of Wine thus depraved and become Æther; that is, if it continue to draw from it the ſmall remaining quantity of the aqueous principle, to which it owes the properties it ſtill retains in common with Spirit of Wine, this muſt produce a total decompoſition thereof; ſo that the oily parts, being no longer diſſolved and divided by the aqueous parts, will be collected together, unite, and appear under their natural form, with all their properties. Now this is exactly the caſe. The Vitriolic Acid riſes in the diſtillation after the Æther; but conſiderably changed, becauſe it is loaded with the ſcattered remains of the decompoſed Spirit of Wine. It is in a manner ſuffocated by the Water it hath attracted from the Spirit; which is the reaſon why it appears in the form of a very aqueous acid liquor. It carries up along with it the Oil which it hath ſeparated from that Water: this is the Oil we took notice of in the proceſs; and it is conſequently that very Oily principle which actually conſtituted the Spirit of Wine. Laſtly, by acting on this Oil alſo, it takes up a portion of phlogiſton, which renders it ſulphureous.

What remains in the retort is alſo a portion of the Oil, that was contained in the Spirit of Wine, now combined with ſome of the Acid; which is the reaſon why it is black and thick. It is a compound much reſembling a Bitumen, and when analyzed yields the ſame principles we obtain from native Bitumens, or from an Eſſential Oil thickened and half-burnt by combining it with concentrated Oil of Vitriol.

As to the Acid of the Spirit of Wine, ſome of it remains combined with the Æther: but there is great reaſon to think, that, when the Vitriolic Acid robs the Spirit of Wine of its aqueous part, it takes up at the ſame time moſt of its Acid, which, being itſelf very aqueous, may be conſidered as pure water with reſpect to the concentrated Oil of Vitriol, by which it is attracted, and with which it is confounded.

The properties which characterize Æther agree perfectly well with what we have ſaid of its nature, and of the manner in which it is produced. It is one of the lighteſt liquors we know; it evaporates ſo ſuddenly, that, if a little of it be dropt on the palm of your hand, you will ſcarce perceive the part it touches to be wet by it; it is more volatile than Spirit of Wine; which is not at all ſurpriſing, ſeeing it differs therefrom only by containing leſs Water, which is the heavieſt principle in Spirit of Wine.

Æther is more inflammable than Spirit of Wine; for, if any flame be brought but near it, it immediately catches fire. The reaſon of this is, that the oily parts of which it conſiſts are not only as much attenuated, and as ſubtile, of thoſe of Spirit of Wine, but alſo in a greater proportion with regard to its aqueous parts. To the ſame cauſe muſt be attributed the facility with which it diſſolves any oily matters whatever.

Æther burns without ſmoke, as Spirit of Wine does, and without leaving any coal or earthy matter behind; becauſe the inflammable or oily parts contained in it are, in this reſpect, diſpoſed like thoſe of Spirit of Wine.

The properties of not being miſcible with water, and of taking up Gold diſſolved in *Aqua Regis*, it poſſeſſes in common with Eſſential Oils; but the latter property it poſſeſſes in a much more ſenſible degree than any Oil: for Eſſential Oils ſuſtain the Gold they thus take up but a little while; whereas the Æther never lets it fall. It ſeems the ancient Chymiſts were unacquainted with the Æther; or at leaſt, if they did know it, they made a myſtery of it, according to cuſtom, and ſpoke of it only in enigmatical terms. Amongſt the moderns Frobenius, a German Chymiſt, ſeems to have been the firſt who brought it to perfection. Godfrey Hankwitz, alſo a German, but ſettled in England, made mention of it much about the ſame time in the Philoſophical Tranſactions. According to the latter, Mr. Boyle and Sir Iſaac Newton both knew the preparation of Æther, for which they had each a different proceſs. But none of theſe Chymiſts ever publiſhed an exact and circumſtantial account of the proceſs by which this liquor may be prepared: ſo that Meſs. Duhamel, Groſſe, and Hellot, who have ſince made ſeveral experiments for that purpoſe, and have diſcovered, and communicated to the publick, eaſy and certain methods of procuring Æther, had no aſſiſtance in their labours but from their own ſkill and ſagacity; which gives them a juſt title to the honour of the invention. Mr. Beaumé alſo, a very ingenious Artiſt in Paris, who hath beſtowed a great deal of pains on this ſubject, lately communicated to the Academy a Memoir, which, among ſeveral very important obſervations, contains the commodious and expeditious proceſs above inſerted. As there are many experiments in Mr. Hellot's Memoir, agreeing perfectly well with what hath been ſaid concerning the decompoſition of Spirit of Wine by the Vitriolic Acid, we think it will be proper to take notice of them here, and to examine them briefly at leaſt.

The quantity, the colour, and the weight of the Oil, which riſes in the diſtillation at the ſame time with the aqueous acid liquor, are various, according to the different proportions of Spirit of Wine and Oil of Vitriol that are mixed together. Mr. Hellot obſerved that by increaſing the quantity of the Vitriolic Acid he obtained more of this Oil, and leſs of the Ardent Spirit containing the Æther. The reaſon is this: the more Oil of Vitriol you put in the mixture, the more Spirit of Wine muſt be totally decompoſed, and conſequently the more of this Oil will be obtained; which, as we have ſhewn, is one of the principles reſulting from the decompoſition of Spirit of Wine.

"This Oil is alſo lighter or heavier, in proportion to the quantity of Oil of Vitriol poured on "the Spirit of Wine. That which ariſes from "mixing ſix, five, four, or even three parts of "Spirit of Wine with one part of concentrated Oil "of Vitriol, always floats on the water, and continues white. That which aſcends from two "parts of Spirit of Wine is yellow, and moſt "commonly ſinks; and, laſtly, that which is

" produced from equal parts of theſe two liquors
" is greeniſh, and conſtantly falls to the bottom."

Mr. Hellot remarks, on this occaſion, that part of the Acid, by the intervention of which this Oil is ſeparated, unites therewith; and, to the greater or ſmaller quantity of the Acid thus combined with the Oil, he imputes its being more or leſs ponderous: which is the more probable, as the heavieſt Oil is always obtained from a mixture in which the Acid bears the greateſt proportion; and *vice verſa.* Perhaps the different ſpecific gravity of Eſſential Oils is wholly owing to the greater or ſmaller quantity of Acid they contain.

Mr. Hoffman hath made ſeveral obſervations on this Oil, which evidently prove that it contains much Acid. He ſays, that, if it be kept for ſome time in a bottle, it grows red, and loſes its tranſparency; that its agreeable aromatic taſte becomes acid and corroſive; and that if you hold it over the fire in a ſilver ſpoon, it corrodes it, and leaves a black ſpot on it; and that it alſo corrodes Mercury, when heated therewith in a matraſs. To this Mr. Pott adds that it makes a very perceptible efferveſcence with Fixed Alkalis; and that being rectified by thoſe ſalts it loſes all the acid properties obſerved by Mr. Hoffman.

Mr. Hellot obtained a ſtill more conſiderable quantity of this Oil, by adding three or four ounces of a Fat Oil to the mixture of Spirit of Wine with the Vitriolic Acid. Now, as the Oil we are ſpeaking of hath the properties of Eſſential Oils, and is ſoluble in Spirit of Wine, Mr. Hellot obſerves that Oil of Vitriol by uniting with Fat Oils converts them into Eſſential Oils: which agrees very well with our opinion concerning the cauſe of the ſolubility of Oils in Spirit of Wine; which, in the Memoir already referred to on other occaſions, we attribute to an Acid ſuperficially and ſlightly united with Oils.

The Oil which thus riſes, in diſtilling Spirit of Wine mixed with the Vitriolic Acid, is known by the name of the *Sweet Spirit of Vitriol.* This name is very improper, becauſe it may ſuggeſt a notion that this Oil derives its origin from the Vitriolic Acid, as ſome Chymiſts have erroneouſly thought; whereas it comes entirely from the Spirit of Wine, as we have ſhewn. If any reaſon can be aſſigned for keeping up the name, it muſt be becauſe of the conſiderable quantity of the Vitriolic Acid that remains in the combination, and is dulcified by its union with the Spirit of Wine.

This Oil is an ingredient in Hoffman's famous *Anodyne Mineral Liquor*. That liquor is thought to be nothing but this very Oil diſſolved, and combined with the two liquors that riſe firſt in the diſtillation, and immediately before the ſulphureous acid phlegm. It diſſolves very eaſily and quickly in thoſe ſpirituous menſtruums: ſo that, if you intend to have it by itſelf, and to prevent its recombining with the liquors that came off before, (which ſhould be prevented, becauſe it hinders the ſeparation of the Æther,) you muſt take great care to change the receiver as ſoon as the acid phlegm, with which it riſes, begins to appear.

We have ſeen that, by the methods which Mr. Hellot hath pointed out, this Sweet Oil of Vitriol may be increaſed, both in weight and quantity. In that ingenious Chymiſt's Memoir we alſo find ſome methods of preventing it from riſing in the diſtillation. They conſiſt wholly in the addition of ſome Abſorbent bodies, which, he tells us, divert the action of the Vitriolic Acid, at leaſt in ſome meaſure, from the inflammable part of the Spirit of Wine. One of theſe methods is as follows.

"Put into Spirit of Wine as much ſoft Soap as
"it can diſſolve: filter it, and pour on it ſome of
"the heavieſt and moſt concentrated Oil of Vitriol:
"ſhake the mixture. The Soap will be inſtantly
"decompounded, and its Oil will float on the ſur-
"face; becauſe the Vitriolic Acid robs it of the
"Alkali, which renders it miſcible with Spirit of
"Wine. Diſtill it, and you will obtain but a very
"little of Rabel's Water; which moreover will
"have the diſagreeable ſmell of a moſt rancid Oil.
"There will afterwards aſcend a great quantity of
"Spirit of Wine having the ſame ſmell; then an
"aqueous, acid, and ſulphureous liquor; but not
"a drop of yellow Oil. Mean time there forms
"a bituminous fungus, of ſome conſiſtence, riſing
"above the Oil of the Soap which floats on the
"reſt of the liquid."

Moſt of the Vitriolic Acid having been abſorbed by the Alkali of the Soap, in this experiment, as Mr. Hellot obſerves, it is not ſurpriſing that it ſhould not act upon the Spirit of Wine with ſo much efficacy as to decompoſe it, and ſeparate its Oil. For the ſame reaſon but a little of Rabel's Water comes over, and almoſt all the Spirit of Wine riſes without undergoing any ſenſible alteration. The diſagreeable ſmell of thoſe liquors comes from the Oil of the Soap, which, being naturally heavy, remains behind in the retort, where it grows rancid and is partly burnt.

The laſt experiment in Mr. Hellot's Memoir, of which we ſhall take notice, is a peculiar proceſs for preparing Æther; by means whereof, with the help of an earthy medium, it is eaſy to diſtill the vinous acid Spirit containing the Æther, without any ſenſible change of ſmell from the beginning to the end of the operation; without its being ſucceeded by an acid ſulphureous liquor, oil, black ſcum, reſin, or bitumen; and without the neceſſity of taking any great care about the management of the fire, as the liquor may always be kept boiling in the retort, and diſtilled to dryneſs without any danger. This medium is common potter's earth. Mr. Hellot puts ſix ounces thereof, well dried and pulverized, into a large retort, with one pound of Spirit of Wine and eight ounces of Oil of Vitriol. Theſe he digeſts together three or four days. The mixture acquires no ſenſible colour. He ſets the retort in a ſand-bath, and continues the diſtillation to dryneſs with a moderate charcoal fire. Excepting a few drops that riſe firſt, and which are pure Spirit of Wine, all the reſt of the liquor that diſtills hath conſtantly the ſmell of Æther; which is even ſomewhat more penetrating than that of the vinous acid Spirit obtained without the intervention of this earthy medium.

We have ſhewn that the production of the æthereal liquor is owing to a ſemi-decompoſition of the Spirit of Wine effected by the Vitriolic Acid during the diſtillation; that this Acid continuing to act produces a total decompoſition, or perfect ſeparation of the Oil and Phlegm of the Spirit of Wine from each other; and that the Vitriolic Acid, uniting with theſe two principles, forms the ſulphureous phlegm, the fluid oil, and the bituminous matter, all frequently mentioned above. Why then, in this experiment of Mr. Hellot's, do we obtain only a Spirit of Wine replete with Æther, while none of the other productions appear? The reaſon is a very natural one, and very clear: it is this; the potter's clay containing an earth of that kind which we called Abſorbent, becauſe it poſſeſſes the property of uniting with Acids, that earth joins with the Vitriolic Acid in the mixture, reduces it to a Neutral Salt, and thereby prevents its continuing to act upon the Spirit of Wine, as is neceſſary to the total decompoſition thereof.

[illegible]

[illegible] two or three [illegible] of [illegible] and [illegible] still [illegible]

[illegible] mixture, [illegible] where [illegible] [illegible] and [illegible] of [illegible] insensibly [illegible] the cavity [illegible] clear, with- [illegible] light [illegible] forming a [illegible] when it [illegible] of two [illegible] true Æther.

" As ſoon as you perceive this track begin to grow " conſiderably narrower, the fire muſt be put out: " for what riſes afterwards will be mixed with water, " and communicate that fault to the Æther already " collected in the receiver.

" Then pour this æthereal liquor into a long bottle, and add to it an equal quantity of well-water. " Shake the bottle; the liquor will become milky, " and the true Æther will inſtantly ſeparate, float " upon the water, and mix no more with it. Separate it then by a ſiphon, and keep it in a " glaſs bottle ſhut cloſe with a glaſs ſtopple."

PROCESS II.

Spirit of Wine combined with Spirit of Nitre. Sweet Spirit of Nitre.

INTO an Engliſh retort of cryſtal glaſs put ſome highly rectified Spirit of Wine; and, by means of a glaſs funnel with a long pipe, let fall into your Spirit of Wine a few drops of the Smoking Spirit of Nitre. There will ariſe in the retort an effervescence attended with heat, red vapours, and a hiſſing noiſe like that of a live coal quenched in water. Shake the veſſel a little, that the liquors may mix thoroughly, and that the heat may be equally communicated to the whole. Then add more Spirit of Nitre, but in a very ſmall quantity, and with the ſame precautions as before. Continue thus adding Spirit of Nitre, by little and little at a time, till you have put into the retort a quantity equal to a third part of your Spirit of Wine. Let this mixture ſtand quiet, in a cool place, for ten or twelve hours; then ſet it to digeſt in a very gentle warmth for eight or ten days, having firſt luted on a receiver to the retort.

During this time a ſmall quantity of liquor will come over into the receiver, which muſt be poured back into the retort. Then diſtill with a ſomewhat ſtronger degree of heat, but ſtill very gently, till nothing be left in the retort but a thick matter. In the receiver you will find a ſpirituous liquor, of a quick grateful ſmell, which will excite a very ſmart ſenſation on the tongue, but without any corroſive acrimony. This is *The Sweet Spirit of Nitre.*

OBSERVATIONS.

By this operation Spirit of Nitre is combined with Spirit of Wine; theſe two liquors being united with each other, much in the ſame manner as the Vitriolic Acid is with Spirit of Wine in Rabel's Water.

The proportion of the liquors which form this combination is not abſolutely determined, and the ſeveral Authors who have written on the ſubject differ much about it. Some require equal parts of the ingredients; others again from two as far as ten parts of Spirit of Wine to one of Spirit of Nitre. This depends on the degree to which the Spirit of Nitre made uſe of is concentrated, and on the greater or leſs acidity which your dulcified Spirit of Nitre is intended to have.

The Diſpenſatory of the College of Paris orders one part of Spirit of Nitre diſtilled from dried clay, that is, of Spirit which doth not ſmoke, to be mixed with two parts of rectified Spirit of Wine, and the whole to ſtand in digeſtion for a month, without diſtilling the mixture at all. This is a very good method; becauſe the long digeſtion ſupplies the place of diſtillation, and the Spirit of Nitre, not being highly concentrated, doth not greatly alter the Spirit of Wine; beſides that many inconveniences, to be preſently taken notice of, are by this means avoided.

But as our deſign is not to deſcribe ſuch Chymical preparations only as are commonly uſed in medicine, our plan requiring us to treat particularly of thoſe which may give any light into the fundamental properties of bodies, the proceſs here ſet down appeared the fitteſt for our purpoſe; becauſe the action which Spirit of Nitre exerts upon Spirit of Wine is therein ſtronger and more perceptible.

One of the firſt particularities, attending the mixture of thoſe two liquors, is the great efferveſcence, accompanied with violent heat, abundance of fumes, and loud hiſſing, which ariſes as ſoon as the Spirit of Nitre and the Spirit of Wine come into contact with each other. There is great reaſon to think that theſe phenomena are produced only by the rapidity and vigour with which the Nitrous Acid ruſhes into union with the inflammable part of the Spirit of Wine. We obſerved, in treating of the Æther, that phenomena of the ſame kind appear at the inſtant when the Vitriolic Acid unites with Spirit of Wine: but on that occaſion, how highly ſoever the Vitriolic Acid be concentrated, all theſe effects are in a leſs degree than thoſe produced in the preſent experiment; becauſe the Nitrous Acid, though weaker than the Vitriolic, generally acts much more vigorouſly and violently on the bodies with which it unites, than any other ſort of Acid.

Concerning theſe mixtures of Acids with Spirit of Wine Mr. Pott obſerves, that it is not a matter of indifference whether you pour the Spirit of Wine upon the Acid, or the Acid on the Spirit of Wine; but that every thing paſſes much more quietly, when the Acid is poured to the Spirit of Wine, than when the contrary is done: and he gives the true reaſon thereof; to wit, that when the Acid is poured on the Spirit of Wine it finds in that liquor

Mr. Hellot ſays on this occaſion “ that part of “ the Vitriolic Acid turning its action on this ſoluble earth or bole, which it finds in the potter's “ clay, ceaſes to act on the inflammable principle “ of the Spirit of Wine; that, conſequently, as “ there is not an immediate and continuous combination of theſe two ſubſtances, neither a reſin nor “ a bitumen can reſult therefrom. This is ſo true “ that a great part of the Oil of Vitriol may be “ afterwards recovered from the potter's clay as “ colourleſs as when it was firſt uſed.”

Mr. Hellot makes uſe of the following method for procuring the Æther from the acid vinous Spirit obtained by this diſtillation. “ You muſt, ſays “ he, put all this liquor into a glaſs body, made “ of one piece with its head; pour upon it, through “ the hole in the upper part of the head, twice or “ thrice as much well-water, the hardeſt to the “ taſte, and the moſt impregnated with gypſum, “ that can be got. Very pure water, he obſerves, “ produces much leſs Æther.

“ If the vinous acid Spirit have ſuch a ſulphureous ſmell, as to occaſion a ſuſpicion that it contains a little too much of a Volatile Vitriolic Acid, “ you muſt add to the water two or three drams of “ Salt of potaſh to abſorb that Acid; and then diſtill “ with a lamp-heat.

“ While any true Æther remains in the mixture, “ you will ſee it aſcend like a white pillar iſſuing “ from the midſt of the liquor, and conſiſting of “ an infinite number of air bubbles inexpreſſibly “ ſmall. Nothing ſeems to condenſe in the cavity “ of the head, which always remains clear, without any viſible humidity. The [illegible] which light “ on the ſides of the receiver, in [illegible] “ net-work thereon, as Spirit [illegible] “ is a little aqueo [illegible] ad [illegible] “ inches or mor [illegible] hey [illegible] another that is quick and fragrant; it doth not afterwards emit any red fumes; it riſes with a leſs degree of heat than when pure; it acts with leſs vigour on Fixed Alkalis and Abſorbent earths. Laſtly, we ſhall here relate an experiment made by that Chymiſt, which ſeems to prove that the Nitrous Acid loſes its moſt characteriſtic properties, and entirely changes its nature, by being combined with Spirit of Wine.

Mr. Pott examined the thick liquor left in the retort when the dulcified Spirit of Nitre is diſtilled off. By analyzing it he obtained an acid liquor, of a yellow colour, and of a ſomewhat empyreumatic ſmell. This Acid was followed by ſome drops of a red empyreumatic Oil; and there remained at the bottom of the diſtilling veſſel a black, ſhining, charred matter, like that which remains after the firſt rectification of a fetid Oil.

The Oil extracted from this reſidue is a portion of that which helped to conſtitute the Spirit of Wine; being ſeparated therefrom by the Nitrous Acid, in the ſame manner as that treated of in the preceding proceſs, and called *Sweet Oil of Vitriol*, is ſeparated by the Vitriolic Acid. But as the Nitrous Acid, which is weaker than the Vitriolic, doth not ſo effectually decompoſe the Spirit of Wine, the Oil obtained in the preſent experiment is in ſmaller quantity than that procured in the diſtillation of a mixture of the Vitriolic Acid with Spirit of Wine.

As to the Acid which Mr. Pott drew off in his experiment, there is great reaſon to think it a part of that which was an ingredient in the mixture, namely, of the Nitrous Acid. And yet Mr. Pott having ſaturated with a Fixed Alkali one part of the reſiduum, which he had a mind to examine before the Acid was ſeparated from it by diſtillation, and expecting this matter to contain a regenerated

Nitre, he threw it on a live coal; but was ſurpriſed to ſee it burn without the leaſt ſign of detonation; and thence concluded that the Nitrous Acid had changed its nature. This experiment, he thinks, may furniſh hints for the tranſmutation of Acids; and he is of opinion that the Nitrous Acid loſes its virtue of detonating, in the preſent caſe, only becauſe its inflammable part, to which it owes its diſtinguiſhing properties, hath deſerted it, and joined with that of the Spirit of Wine.

Indeed, if the Acid obtained by Mr. Pott, which being reduced to a Neutral Salt doth not detonate, derives its origin from the Nitrous Acid that was combined with the Spirit of Wine, there is no doubt of its being depraved in a peculiar manner, and having entirely changed its nature. But may we not ſuppoſe it to have another origin? May it not be the Acid of the Spirit of Wine itſelf, reſulting from the decompoſition of that mixt in the diſtillation?

Mr. Navier, whom we mentioned in our Elements of the Theory, extracted a very ſingular oily liquor from the mixture of Spirit of Wine and Spirit of Nitre, without diſtillation, and even without the help of fire. He put equal parts of the two liquors, by meaſure, not by weight, into a bottle, which he ſtopped cloſe with a good cork, faſtened down with pack-thread. Nine days afterwards he found about a ſixth part of the mixture ſeparated from, and floating on, the reſt of the liquor. This was a very fine æthereal Oil, very limpid, and almoſt as colourleſs as water.

In another experiment Mr. Navier ſubſtituted a ſolution of Iron in the Nitrous Acid for pure Spirit of Nitre; and with this ſolution he mixed an equal weight of Spirit of Wine. From the mixture, after a fermentation which appeared in it, he obtained by the ſame method an æthereal Oil, like that of his former experiment; except that the latter, which was at firſt as colourleſs as the other, acquired a redneſs in the ſpace of about three weeks. He conjectures, with probability, that this colour proceeded from ſome particles of Iron which were united with it, and which gradually exhaled.

If a few drops of Oil of Tartar *per deliquium* be poured on this Oil as ſoon as it is ſeparated, there appears at firſt no ſenſible change therein: but after ſome time needle-like cryſtals ſhoot in it, which are a true regenerated Nitre; and if the bottle be then unſtopped, the liquor emits a moſt pungent nitro-ſulphureous odour; which leaves no doubt of this Oil's containing a Nitrous Acid. When it is thus freed of its Acid, by means of the Oil of Tartar, it is much more volatile than before.

Neither the Vitriolic nor the Marine Acid is capable of ſeparating ſuch an Oil from Spirit of Wine: but the Nitrous Acid always produces it, even when it is not concentrated, and doth not ſmoke.

It is very certain that this Oil derives its origin from the Spirit of Wine: but there are not yet experiments enough made upon it to enable us to ſpeak very accurately about the manner in which this liquor is formed, or of the cauſe of its ſeparation from the Spirit of Wine.

PROCESS III.

Spirit of Wine combined with the Acid of Sea-ſalt. Dulcified Spirit of Salt.

MIX together, little by little, in a glaſs retort, two parts of Spirit of Wine with one part of Spirit of Salt. Set this mixture to digeſt for a month in a gentle heat, and diſtill it, till nothing remain in the retort but a thick matter.

OBSERVATIONS.

THE Acid of Sea-ſalt is much leſs diſpoſed to unite with inflammable matters than the other two mineral Acids; and therefore, though it be ever ſo highly concentrated when mixed with Spirit of Wine, it never produces an effervеſcence comparable to that which is produced by the Spirit of Nitre. Neither the proportion nor ſtrength of the Spirit of Salt, requiſite to prepare the Sweet Spirit of Salt, are unanimouſly agreed upon by Authors. Some direct equal parts of the two liquors; while others preſcribe from two to four or five parts of Spirit of Wine to one part of Spirit of Salt. Some uſe only common Spirit of Salt; others require the Smoking Spirit diſtilled by means of Spirit of Vitriol. Laſtly, ſome order the mixture to be diſtilled, after ſome days digeſtion; and others content themſelves with barely digeſting it. The whole depends on the degree of ſtrength which the Sweet Spirit of Salt is intended to have. This compoſition, as well as the Sweet Spirit of Nitre, is eſteemed in medicine to be very aperitive and diuretic.

When the mixture of Spirit of Salt and Spirit of Wine is diſtilled, there comes over but one liquor, which appears homogeneous. This is the Sweet Spirit of Salt. The nature of the Marine Acid is not changed in this combination: the Acid is only weakened and rendered more mild; but in other reſpects it retains its characteriſtic properties.

Some Authors pretend that an Oil is obtained by diſtilling the mixture for the Sweet Spirit of Salt; but others expreſsly deny the fact. This variety may be occaſioned by the quality of the Spirit of Wine employed. It would not be ſurpriſing if a Spirit of Wine, which contains much Oil that is unneceſſary to its nature, and, as it were, adventitious to it, ſhould yield an Oil when diſtilled with Spirit of Salt.

The thick reſidue, found in the retort after diſtillation, contains the moſt ponderous part of the Acid, united with part of the Spirit of Wine. If the diſtillation be continued to dryneſs, there remains in the retort a black charred matter, much like that which is left by the combinations of Spirit of Wine with the other Acids.

A Sweet Spirit of Salt may alſo be prepared by digeſting Spirit of Wine with, or diſtilling it from, metallic compoſitions replete with the Marine Acid adhering but ſlightly to them; ſuch as Corroſive Sublimate, and Butter of Antimony. Part of this Acid, which is very highly concentrated, quits the metallic ſubſtance with which it is but ſuperficially combined, in order to unite with the Spirit of Wine. If Butter of Antimony be uſed for this purpoſe, Mr. Pott, the Author of theſe experiments, obſerves that a *Mercurius Vitæ* precipitates; which is nothing elſe, as we obſerved in its place, but the reguline part of the Butter of Antimony deſerted by its Acid.

PROCESS IV.

Oils, or Oily matters, that are ſoluble in Spirit of Wine, ſeparated from Vegetables, and diſſolved by means of that Menſtruum. Tinctures; Elixirs; Varniſhes. Aromatic ſtrong waters.

PUT into a matraſs the ſubſtances from which you intend to extract a Tincture, having firſt pounded them, or pulverized them if they are capable of it. Pour upon them Spirit of Wine to the depth of three fingers breadth. Cover the matraſs with a piece of wet bladder, and tie it on with packthread. Make a little hole in this bit of bladder with a pin, leaving it in the hole to keep it ſtopped. Set the matraſs in a ſand-bath very gently heated. If the Spirit of Wine diſſolve any part of the body, it will accordingly acquire a deeper or lighter colour. Continue the digeſtion till you perceive that the Spirit of Wine gains no more colour. From time to time pull out the pin, to give vent to the vapours, or rarefied air, which might otherwiſe burſt the matraſs. Decant your Spirit of Wine, and keep it in a bottle well corked. Pour on ſome freſh Spirit in its ſtead; digeſt as before; and go on in this manner, pouring on and off freſh Spirit of Wine, till the laſt come off colourleſs.

OBSERVATIONS.

IT is commonly ſaid that Spirit of Wine is the ſolvent of Oils and oily matters: but this propoſition is too general; for there are ſeveral ſorts of Oils and oily matters which this menſtruum will not diſſolve. Of this number are the Fat Oils, Bees-Wax, and the other Oily compounds of that kind. Properly ſpeaking, it diſſolves but two ſorts of oily ſubſtances; namely, Eſſential Oils, and Balſams or Reſins, which are matters of the ſame kind, differing from each other only as they are more or leſs thick; and Oils that are in a ſaponaceous ſtate.

In our Elements of the Theory we have explained our opinion on this head, from a Memoir on the ſubject printed among thoſe of the Academy for 1745. To repeat it in a few words: we take the cauſe of the ſolubility of Oils in Spirit of Wine to be an Acid, which is but ſuperficially united with them, and ſo as ſtill to retain its properties.

The principal proofs on which we found this opinion are drawn from that property of Eſſential Oils, Balſams, and Reſins, which are naturally ſoluble in Spirit of Wine, that they become ſo much the leſs ſoluble in this menſtruum, the oftener they are diſtilled or rectified; and from that which Fat Oils, or other Oily matters, naturally indiſſoluble in Spirit of Wine, poſſeſs of becoming more and more ſoluble therein the oftener they are diſtilled. We ſhewed that diſtillation leſſens the ſolubility of Eſſential Oils, Balſams, and Reſins, only by depriving theſe ſubſtances of part of the manifeſt Acid which they contain, and which is the cauſe of their ſolubility; and that Fat Oils, and other oily matters, naturally indiſſolvable in Spirit of Wine, are by the ſame operation rendered capable of diſſolving therein, only becauſe it diſcovers and partly extricates an Acid, which is naturally combined with them ſo intimately that it is entirely deprived of action, and all its properties perfectly maſked. If theſe principles be well attended to, and if it be recollected withall, that Spirit of Wine unites with Water preferably to Oils; inſomuch that if it be mixed with water when it hath diſſolved an Oil, it quits the Oil to unite with the water; that for the ſame reaſon it is not capable, when very aqueous, of diſſolving any Oil, ſeeing that as Oil and water are not ſuſceptible of contracting any union, it muſt then deſert its phlegm to unite with the Oil; which it cannot do, becauſe it hath a greater affinity with phlegm than with Oil; and, laſtly, that if Oil be combined with any ſaline ſubſtance, which makes it ſoluble in water; that is, if it be in a ſaponaceous ſtate, it will then remain diſſolved in Spirit of Wine, without being precipitated by water, or will be diſſolved by a very aqueous Spirit of Wine, and frequently much better than by a highly rectified Spirit: if theſe things, I ſay, be conſidered, we ſhall eaſily perceive what muſt be the effect of digeſting Spirit of Wine with any vegetable ſubſtance whatever.

Spirit of Wine diſſolves all the Eſſential Oil, Balſam, and Reſin contained in any vegetable; and as theſe matters are not ſoluble in water, they may be ſeparated from the Spirit in which they are diſſolved, by lowering it with much water. It inſtantly becomes white and opaque, like milk; the oily parts gradually unite, and form conſiderable maſſes, eſpecially if they be reſinous. This is the method commonly made uſe of to extract the Reſins of Scammony, Jalap, Guaiacum, and ſeveral other vegetable ſubſtances, which it would be difficult to procure by any other means.

If the matters digeſted with Spirit of Wine contain any ſaponaceous juices, the Spirit will take up thoſe juices alſo. But as Soaps are ſoluble in water, as well as in Spirit of Wine, they cannot be ſeparated by the addition of water from the Spirit in which they are diſſolved. Whatever quantity of water therefore you mix with a Spirit that is impregnated with ſuch juices, no ſeparation thereof will be produced; and for the ſame reaſon the ſaponaceous matters will be diſſolved by a very aqueous Spirit of Wine.

Spirit of Wine impregnated with ſuch parts of any vegetable ſubſtance as it is capable of diſſolving is commonly called a *Tincture.* Several Tinctures mixed together, or a Tincture drawn from ſundry vegetable ſubſtances at the ſame time, and in the ſame veſſel, take the name of an *Elixir.* Tinctures or Elixirs impregnated with Reſinous matters only are true *Varniſhes.* All theſe preparations are made in the ſame mannner; to wit, as directed in our proceſs. We ſhall only add here that if the ſubſtances from which a Tincture or Elixir is to be made contain too much moiſture, it is proper to free them from it by gentle deſiccation; eſpecially if you deſign that the Tincture ſhould be well impregnated with the oily and reſinous parts:

for their exceſs of moiſture uniting with the Spirit of Wine would weaken it, and render it unable to act on thoſe matters, which it cannot diſſolve when it is aqueous.

Vegetable ſubſtances which have been repeatedly digeſted with different parcels of Spirit of Wine, till the laſt would extract nothing, are deemed to be exhauſted of all their Eſſential Oils, and ſaponaceous juices: but if they contain moreover any Fat Oil, Wax, or Gum, theſe principles will ſtill remain therein after the digeſtion, in the ſame quantity as before; becauſe Spirit of Wine is incapable of diſſolving them.

With regard to the Fat Oil and Wax, this is not at all ſurpriſing: we have explained in another place why theſe matters are indiſſoluble by Ardent Spirits: but as for the Gum, it would ſeem, according to the general principles abovementioned, that it ſhould be ſoluble in that menſtruum, even with more eaſe than Reſins; as it conſiſts almoſt entirely of water, with which Spirit of Wine is known to unite more eaſily than with Oils. Indeed there is alſo a little Oil in its compoſition: but this Oil ſeems to be in a perfectly ſaponaceous ſtate; for Gum diſſolves wholly and eaſily in water, without leſſening its tranſparency in the leaſt.

I own that it is extremely difficult to give a very ſatisfactory account of this matter. We may however venture to throw out ſome conjectures concerning it, deduced from what hath been already ſaid, relating to the cauſe of the ſolubility of Oils in Spirit of Wine. We ſhewed that the Oils which diſſolve in this menſtruum derive that property from a manifeſt Acid, which is united with them but ſuperficially, and in ſuch a manner as to retain all its virtue; but that if this ſame Acid be too intimately united with the Oil, ſo as to have no manifeſt power, but be in a manner deſtroyed, and, converted as it were into a Neutral Salt, it will not then produce this effect.

A modern Author * relates two experiments which agree very well with this opinion, and indeed confirm it. He mixed together Oil of Vitriol and Oil of Turpentine, with a view to imitate by art a bituminous matter; which, we know, is not at all, or at leaſt ſcarcely, ſoluble in water. Theſe two matters being united together produced a red, thick compound, which by evaporation became like a natural Bitumen.

The Author obſerves that when this mixture is juſt made it diſſolves in Alkohol; but that in ſome time it changes its nature, and communicates ſcarce any part of its ſubſtance to that ſolvent. Now whence can this difference ariſe, but from this, that when the mixture is new, the Acid is as yet but ſuperficially united with the Oil, and combines with it more and more intimately, as the mixture grows older.

The ſame Author, having repeated the experiment with Spirit of Vitriol, obtained a compound which continued always very ſoluble in Spirit of Wine: becauſe Spirit of Vitriol being much weaker and more aqueous than Oil of Vitriol, was incapable of combining ſo cloſely with the Oil of Turpentine, as that concentrated Acid did in the former experiment. By the by, there is great reaſon to believe that the very intimate union of a mineral Acid with an oily matter is the true cauſe why Bitumens will not diſſolve in Spirit of Wine.

It ſeems therefore pretty probable that the Acid which makes the Oil of Gummy matters ſoluble in water, and reduces it to a ſaponaceous ſtate, is ſo intimately united with that Oil, that it loſes its proper-

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* Mr. Eadows, in a little Engliſh Book, entitled the *Modern Apothecary*.

perties, and is in a manner converted into a Neutral Salt. Now we know that ſuch Salts are ſoluble in water, but are not ſo, for the moſt part, in Spirit of Wine.

If your Tinctures or Elixirs be not ſo ſtrong or ſo ſaturated as you deſire, you may by diſtillation abſtract part of the Spirit of Wine which they contain, and by that means give them ſuch a degree of thickneſs as you judge proper. But the Spirit of Wine thus drawn off conſtantly carries along with it a good deal of the aromatic principle. It is a truly *Aromatic ſtrong water.* This Spirit of Wine alſo carries up with it a portion of thin Oil, which is ſo much the more conſiderable as the degree of heat employed is greater: and this is the reaſon why it becomes of a milky colour when mixed with water.

If you intend to make an Aromatic ſtrong water only, you need not previouſly extract a Tincture from the vegetable ſubſtance with which you mean to prepare your water: you need only put it in a cucurbite, pour Spirit of Wine upon it, and diſtill with a gentle heat. By this means you will obtain a Spirit of Wine impregnated with all the odour of the plant.

CHAP. III.

OF TARTAR.

PROCESS I.

Tartar analyzed by diſtillation. The Spirit, Oil, and Alkaline Salt of Tartar.

INTO a ſtone retort, or a glaſs one coated with lute, put ſome white Tartar broken into ſmall bits; obſerving that one half, or at leaſt a full third, of the veſſel be left empty. Set your retort in a reverberating furnace. Fit on a large ballon, having a ſmall hole drilled in it; lute it exactly with fat lute, and ſecure the joint with a linnen cloth ſmeared with lute made of quick-lime and the white of an egg. Apply at firſt an exceeding gentle heat, which will raiſe a limpid, ſouriſh, pungent water, having but little ſmell, and a bitteriſh taſte.

When this firſt phlegm ceaſes to come off, increaſe your fire a little, and make the degree of heat nearly equal to that of boiling water. A thin, limpid Oil will riſe, accompanied with white vapours, and with a prodigious quantity of air, which will iſſue out with ſuch impetuoſity, that if you do not open the little hole in the receiver time enough to give it vent, it will burſt the veſſels with exploſion. An acid liquor will riſe at the ſame time. Continue the diſtillation, increaſing the heat by inſenſible degrees, and frequently unſtopping the little hole of the receiver, till the elaſtic vapours ceaſe to iſſue, and the oil to diſtill.

Then raiſe your fire more boldly. The acid Spirit will continue to riſe, and will be accompanied with a black, fetid, empyreumatic, ponderous, and very thick Oil. Urge the fire to the utmoſt extremity, ſo that the retort may be of a perfect red heat. This violent fire will raiſe a little Volatile Alkali, beſides a portion of Oil as thick as pitch. When the diſtillation is finiſhed, you will find in the retort a black, ſaline, charred matter, which grows hot when wetted, attracts the moiſture of the air, runs *per deliquium*, and hath all the properties of a Fixed Alkali.

The maſs, being expoſed to a naked fire in the open air, burns, conſumes, and is reduced to a white aſh, which is a fiery, cauſtic, Fixed Alkali.

OBSERVATIONS.

THE matters qualified to produce a ſpirituous liquor by fermentation do not all contain the juſt and accurate proportion of Acid neceſſary to conſtitute an Ardent Spirit. Many of them, the juices of fruits for inſtance, and eſpecially that of the Grape, are replete with a ſuper-abundant quantity of Acid, more than concurs to form that product of fermentation. This ſuper-abundant Acid, combined with ſome of the Oil and earth contained in the fermented liquor, produces a ſort of Salt, which hangs for a while ſuſpended in that liquor, but after ſome time, when the Wine ſtands quiet in a cool place, ſeparates from it, and forms a ſtone-like incruſtation on the inſide of the vat in which the Wine is kept. This matter is called *Tartar*.

The Lees of Wine reſemble Tartar, in as much as they contain, and yield when analyzed, the ſame principles; but they differ from it in this, that they contain, moreover, a greater quantity of earth, of phlegm, and a little Ardent Spirit, which are only mixed, but not united, with its tartarous Acid.

The reſidue, or ſort of extract, which remains in the cucurbite after Wine hath been deprived of its Ardent Spirit by diſtillation, hath alſo a great conformity with Tartar. It even contains that portion of Tartar which remained ſuſpended in the Wine at the time of its diſtillation: and accordingly this reſidue of Wine, being analyzed, yields the ſame principles with Tartar.

Hence we ſee that liquors, which have undergone the ſpirituous fermentation, conſiſt of an Ardent Spirit and a Tartarous Acid ſuſpended in a certain quantity of Water.

In the analyſis of Tartar there are ſeveral things worthy of notice. The firſt is the vaſt quantity of Air which this mixt body yields when it begins to be decompoſed. The chief difficulty attending its analyſis ariſes from this air; which iſſues out and exerts its elaſtic force with ſuch impetuoſity, that all the precautions above mentioned are no more than neceſſary to prevent the burſting of the veſſels.

The ſingular nature of the thin limpid Oil, which riſes with this air, after the firſt acid phlegm, deſerves likewiſe our particular attention. This Oil is one of the moſt penetrating we know. Boerhaave, who diſtilled Tartar without having a vent-hole in his receiver, was obliged, in order to prevent its burſting, to apply it to his retort with a lute ſo weak that moſt of the elaſtic vapours might perſpire through it; and he obſerved, that, though the neck of his retort entered above five inches into the mouth of his receiver, and was luted on as cloſely as poſſible with ſuch a lute, yet this light Oil of Tartar conſtantly returned back again, as it were, and pervaded the ſubſtance of the lute, ſo that a good deal of it dropped into a diſh placed on the outſide on purpoſe to receive it. This Oil is probably rendered ſo active and ſubtile, only by having been exceedingly attenuated by the fermenting motion. This experiment is one of thoſe which ſufficiently prove the neceſſity of employing receivers having a ſmall vent-hole, that may be opened and ſhut as occaſion requires.

The laſt remark we ſhall make, on the productions of Tartar by diſtillation, relates to the *caput mortuum* found in the retort when the operation is finiſhed. This reſidue is very different from that which other vegetable matters afford: for, when they are decompoſed in cloſe veſſels, they leave nothing but a mere charred matter, in which no ſaline property appears, and from which no Fixed Alkali can be obtained, but by carrying their analyſis to the utmoſt; that is, by burning them in the open air. Tartar on the contrary, only by being diſtilled in cloſe veſſels, without burning it afterwards in the open air, is changed into a ſubſtance which hath all the properties of a Fixed Alkali. This is probably owing to the Tartar's containing the principles requiſite to form a Fixed Alkali in a much greater quantity than they are to be found in any other ſubſtance. As Tartar thus alkalizated in cloſe veſſels ſtill contains much inflammable matter, it might be employed with advantage as a reducing flux in ſeveral operations of metallurgy.

Of all the vegetable matters we know, calcined Tartar yields the greateſt quantity of Fixed Alkali; which is likewiſe very pure, and therefore much uſed in Chymiſtry.

Burnt Lees of Wine alſo afford a great quantity of Fixed Alkali, which is of the ſame nature with that of Tartar. This Salt is uſed in different trades, and particularly in dying. The French Vinegar-makers collect quantities of theſe Lees, which they make up into cakes and dry: while it is in this ſtate they call it *Gravelle* or *Gravelée*; and *Cendre Gravelée* when it is burnt.

If the extract of Wine, which remains after the Spirit is drawn off, were gently evaporated to dryneſs, and that dry matter burnt like Tartar or *Gra-*

velle, it would be a ſort of *Cendre gravelée* very rich in alkaline Salt.

PROCESS II.

The Depuration of Tartar. Cream and Cryſtals of Tartar.

REDUCE to a fine powder the Tartar you intend to purify, and boil it in twenty five or thirty times as much water. Filter the boiling liquor through a flannel-bag, and then gently evaporate ſome part of it: there will ſoon form on its ſurface a ſaline cruſt, which is the *Cream of Tartar*. Let your liquor cool, and there will adhere to the ſides of the veſſel a great quantity of a cryſtallized ſaline matter, which is *Cryſtal of Tartar*.

OBSERVATIONS.

TARTAR, when taken out of the vats in which it forms, is mixed with a conſiderable quantity of earthy parts, which are not intimately united therewith, but adulterate it. This extraneous earth makes about two fifths of the whole weight of common Tartar; but white Tartar, which is the beſt, contains but about a third part of earth.

The method of refining Tartar, and freeing it from this adventitious earth, is very ſimple, as appears from the proceſs. Earthy matters, which are not intimately combined with an Acid in the form of a Neutral Salt, are not diſſoluble in water: for which reaſon the water, in which crude Tartar is boiled, diſſolves the ſaline part only, which paſſes with it through the filter; but doth not diſſolve the earth of the Tartar, becauſe that earth is not combined with the ſaline part, and ſo being only ſuſpended in the liquor remains on the filter.

The ſaline parts of the Tartar, though they are now ſeparated from the groſs earth with which they were mixed, are not yet perfectly pure. Theſe firſt Cryſtals of Tartar have a diſagreeable ruſſet colour, and are not tranſparent: this is owing to their being coated over, as it were, with a fatty matter, which alſo is foreign to their nature, and may be ſeparated from them without decompoſing them in the leaſt.

The Cryſtals of Tartar are but ſeldom perfectly depurated in Chymical Laboratories; becauſe the operation doth not uſually ſucceed well on ſmall quantities: but there are manufactories which do it by the great, and ſupply the Chymiſts, as well as the ſeveral tradeſmen, with very fine and very pure Cryſtals of Tartar. Theſe manufactories are chiefly ſet up in the neighbourhood of Montpellier. Mr. Fiſes, a celebrated Profeſſor of Medicine, hath in the Memoirs of the Academy for 1725 deſcribed the operation as performed in one of theſe works. He tells us that having ſeparated the earthy part from the Cryſtals of Tartar, by boiling and filtering, they diſſolve them again, and boil them in large caldrons, mixed with a white ſaponaceous earth, which cleanſes and whitens them to perfection.

The ſaponaceous earth is found near the works; but it is not the only one that may be employed for this purpoſe, ſince, as Mr. Fiſes obſerved, they have ſucceſſively made uſe of ſeveral different earths in that very work, and that the earth they now uſe hath not been long employed. There is reaſon to think that moſt ſaponaceous earths might anſwer the purpoſe of refining Cryſtal of Tartar: but one neceſſary condition is that they be altogether indiſſoluble by Cryſtal of Tartar, which being acid diſſolves many ſorts of earth; for, if they had not this quality, they would form a Neutral Salt with the ſaline part of the Tartar, the nature of which they would intirely change, and convert it into ſoluble Tartar, as will appear by the experiments that follow.

CHAP. IV.

CRYSTAL OF TARTAR COMBINED WITH SEVERAL SUBSTANCES.

PROCESS I.

Cryſtal of Tartar combined with Abſorbent Earths. Soluble Tartars.

BOIL an Abſorbent Earth, ſuch as Chalk, in a pan with water; and, when you perceive the Earth thoroughly divided and equally diſtributed through the water, throw into the pan, from time to time, ſome pulverized Cryſtal of Tartar, which will excite a conſiderable effervefcence. Continue theſe projections, till you obſerve no effervefcence excited thereby. All the Abſorbent Earth, which obſcured the tranſparency of the water, and gave it an opaque white colour, will gradually diſappear as the Cryſtal of Tartar combines with it; and when the combination is perfected, the liquor will be clear and limpid. Then filter it, and there will be left on the filter but a very ſmall quantity of Earth. Evaporate all the filtered liquor with a gentle heat; and then ſet it in a cool place to ſhoot. Cryſtals will form therein, having the figure of flat quadrangular priſms, with almoſt always one, ſometimes two, of the angles of the priſm ſhaved down, as it were; and then the ſurfaces at each end are oblique anſwering to thoſe depreſſed angles. Theſe cryſtals are a Neutral Salt which readily diſſolves in water; a true *Soluble Tartar.*

OBSERVATIONS.

CRYSTAL of Tartar is a ſaline ſubſtance of a ſingular nature. Though it cryſtallizes like a Neutral Salt, yet it is not one: it hath only the form of one; its principal properties being thoſe of an Acid. Nevertheleſs it is not a pure Acid; for it is united with a certain quantity of Oil and of earth, which give it the property of cryſtallizing, and is ſcarce diſſolvable in water. It is a middle ſubſtance between an Acid and a Neutral Salt. It is an Acid half-neutralized; on which account it is capable of acting like an Acid on all ſubſtances ſoluble by Acids, and ſo of being converted into a perfectly Neutral Salt by combining with them to the point of ſaturation.

In the experiments made to neutralize Cryſtal of Tartar, Fixed Alkaline Salts alone were formerly uſed. Meſſ. Duhamel and Groſſe were the firſt who diſcovered that Abſorbent Earths might be ſubſtituted for Alkalis, and would produce nearly the ſame effects on Cryſtal of Tartar. The experiments made by theſe two Academicians in conjunction are circumſtantially related in two curious Memoirs on this ſubject, given in by them jointly, and printed with thoſe of the Academy for 1732 and 1733. From theſe Memoirs we took the proceſs here given, and ſhall alſo borrow from thence moſt of the remarks we are now going to make.

Stone-lime holds, as it were, the middle place between mere Abſorbent Earths and Fixed Alkalis. Now, ſeeing Cryſtal of Tartar may be converted into a Neutral Salt by either of theſe two ſubſtances, it follows that lime ought to produce the ſame effect upon it. Accordingly Meſſ. Duhamel and Groſſe found it to be ſo upon trial; having formed, with *Lac Calcis* and Cryſtal of Tartar, a Neutral Salt perfectly like that which reſults from the union of that ſaline matter with Chalk. *Cremor calcis*, or that ſalino-terrene pellicle which forms on lime-water, produced the ſame effect: but, what is moſt ſingular is, that lime-water itſelf, though it be clear and limpid, and conſequently doth not ſeem to contain any earthy particles, produced nevertheleſs a great effervеſcence with Cryſtal of Tartar, and neutralized it as perfectly as *Cremor calcis*, or water ever ſo much impregnated with Chalk. This ariſes from hence that a great quantity of the ſalino-terrene matter, which forms the *Cremor calcis*, is diſſolved in the lime-water.

Though lime-water neutralizes Cryſtal of Tartar as perfectly as Chalk does, and though the Cryſtals of Soluble Tartar, or Neutralized Tartar, thereby produced, be like thoſe which have Chalk for their baſis, yet Meſſ. Duhamel and Groſſe obſerved ſome differences worthy of notice between the phenomena accompanying the production of theſe two Neutral Salts, which reſemble each other ſo much that they ſeem but one and the ſame ſpecies of Salt. The principal difference conſiſts in this, that the water containing the Tartar neutralized by Chalk is very limpid, and leaves but a very ſmall quantity of earth on the filter; whereas the lime-water with which Tartar is neutralized leaves on the filter a conſiderable quantity of earth.

This muſt appear the more ſurpriſing that the water replete with Chalk was, before its union with the Cryſtal of Tartar, turbid and opaque; whereas the lime-water was clear and limpid at the firſt. Meſſ. Duhamel and Groſſe ſuſpect this to ariſe from hence, that the effervеſcence excited, while the Cryſtal of Tartar diſſolves the matter contained in lime-water, is greater than that which is produced by its union with Chalk ſuſpended in water.

" If we conſider, ſay they, that in a great effer-" vеſcence a conſiderable quantity of the acid " Spirit is evaporated, we ſhall eaſily perceive, that, " the more of that Spirit eſcapes, the more of the " earth of the Tartar will be precipitated. Now, " as the effervеſcence with lime-water is more conſi-" derable, and as there is leſs alkaline earth to " check, as it were, and reſtrain the Acid, than in " the experiment with Chalk, a greater quantity of " the acid Spirit may eſcape; which being entirely " loſt will cauſe more earth to precipitate in " this caſe than in the other, where the Acid is at " once attracted by a great deal of alkaline earth: " and accordingly this was the reaſon that our Tar-" tar diſſolved by Chalk depoſited, in cryſtallizing, " a grey earth, which was ſcarce perceivable in the " experiment made with lime-water.

" Yet perhaps, ſay they, an Acid, which we " ſuſpect to be contained in lime, may have partly " occaſioned the precipitation of this earth." The exiſtence of this Acid, which theſe gentlemen at that time only ſuſpected, hath been ſince demonſtrated by ſeveral experiments, and particularly by thoſe which Mr. Malouin hath publiſhed. This Acid is the Vitriolic, which in combination with ſome of the earth of the lime forms a ſort of Selenitic Salt; which adds greatly to the probability of Meſſ. Duhamel and Groſſe's laſt conjecture. I ſhall now explain how I conceive the Vitriolic Acid in lime may occaſion the copious precipitate which falls in lime-water, when Cryſtal of Tartar is neutralized by it.

The quantity of Vitriolic Acid contained in lime is very inconſiderable; ſo that to convert it into a Neutral Salt requires its intimate union with a very ſmall quantity of the earthy and abſorbent parts. Hence it comes to paſs, that, when water is poured upon Quick-lime, in order to make Lime-water, it in ſome ſort divides the lime into two parts. All the particles of Abſorbent Earth, which had not contracted an union with the Acid, are at firſt barely ſuſpended in the liquor, the tranſparency of which they deſtroy, giving it an opaque white colour; and this is what makes the *Lac calcis:* but they ſoon ſeparate from it, and fall to the bottom, in the form of a precipitate; becauſe they are not ſoluble in water. By this precipitation the liquor becomes limpid, and remains impregnated only with ſuch of the earthy parts as are united with the Vitriolic Acid, in the form of a kind of Neutral Salt, and have by that union acquired ſolubility. But as the Vitriolic Acid found many more Abſorbent parts in the lime than were neceſſary to neutralize it, it in a manner over-doſed itſelf with earthy parts, and thereby exceeded the bounds of a perfect neutrality.

On the other hand, it hath been ſhewn that Cryſtal of Tartar is an imperfect Neutral Salt. Now theſe two Salts, which are neither of them perfectly Neutral, differ from a perfectly Neutral Salt by properties directly oppoſite to each other; ſeeing the Selenitic matter in Lime exceeds in its abſorbent or alkaline quality, and Cryſtal of Tartar exceeds, on the contrary, in acidity.

What muſt be the conſequence, therefore, of mixing theſe two ſaline matters together? The ſame as when an Acid is mixed with a Fixed Alkali; that is, the Salt which exceeds in acidity will combine with the ſuper-abundant alkaline earth of the Selenitic Salt; ſo that theſe two ſaline matters will both become perfectly Neutral Salts. Yet theſe two Neutral Salts have not the ſame degree of ſolubility in water. The neutralized Cryſtal of Tartar diſſolves very readily in water, and is for that reaſon called Soluble Tartar: the Selenitic Salt, on the contrary, is hardly diſſolvable in it at all. Now the rule is, when two Salts of this nature meet together, that which is the moſt ſoluble always remains united with the water, excluſive of the other, which is forced to precipitate. This I imagine to be what happens in the preſent caſe; and the precipitate which we ſee fall, in the lime-water employed to neutralize Cryſtal of Tartar, ſeems to me to be no other than the Selenitic Salt of the Lime; which, being leſs ſoluble than the neutralized Tartar, gives place to it, and ſeparates from the liquor.

Indeed we cannot, in my opinion, account for the precipitate under conſideration, any other way than by ſuppoſing it to be a portion either of the earth of the Cryſtal of Tartar, or a portion of the Lime. Now, either of theſe earths may be diſſolved by Acids; whereas the precipitate in queſtion, according to the obſervations of Meſſ. Duhamel and Groſſe, is not ſo: and this ought to be the caſe, if the precipitate be nothing but the Selenitic Salt of the Lime, which being a Neutralized Salt, partly conſtituted by the moſt powerful of all the Acids, muſt be unalterable by any Acid whatever.

Meſſ. Duhamel and Groſſe made a great many experiments on the combinations of Cryſtal of Tartar with different ſorts of earths. The reſult of the whole is, that there are ſome earths which this Acid diſſolves, and which contract ſuch an union with Cryſtal of Tartar, that they not only change its external character, that is, its tendency to cryſtallize, and its indiſſolubleneſs in cold water, but alſo entirely alter its taſte and other qualities. In a word, thoſe earths produce on this Salt all the effects of alkaline Salts. Theſe earths are ſuch as are called Abſorbent Earths; ſtone-lime, animal-lime, cretaceous earths, a portion of calcined gypſum, and of potaſh; in ſhort, all ſuch as diſtilled vinegar is capable of diſſolving: this is the mark by which thoſe earths, which are qualified to neutralize Cryſtal of Tartar and to render it ſoluble, may be diſtinguiſhed.

Meſſ. Duhamel and Groſſe found alſo upon trial that there are other earths, on the contrary, which are, in a manner, inacceſſible to the Acid of Cryſtal of Tartar; that they take up, indeed, the groſſeſt and redundant Oil of the Tartar, but without affecting its ſaline part at all: and if theſe earths are ever obſerved to form any union with the Cryſtals of Tartar, as happens in the refining houſes near Montpellier, that union is only ſuperficial, not intimate; and therefore it alters none of the characters of the Salt. Among theſe earths are the clayey, bolar, ſandy earths, and others of that kind. Hence Meſſ. Duhamel and Groſſe conclude that theſe are the earths which ought to be employed in the purification and whitening of Cryſtal of Tartar. Vinegar is here alſo the teſt by which it may be known whether an earth intended for this purpoſe be fit for it: for you may be ſure that it will form no union with Cryſtal of Tartar, if the Acid of Vinegar be incapable of diſſolving it.

PROCESS II.

Cryſtal of Tartar combined with Fixed Alkalis. The Vegetable Salt. Saignette's Salt. The decompoſition of Soluble Tartars.

IN eight parts of water diſſolve one part of a very pure alkaline Salt, perfectly freed from the phlogiſton by calcination. Heat this lixivium in a ſtone pan ſet on a ſand-bath, and from time to time throw into it a little powdered Cream or Cryſtal of Tartar. Each projection will excite a great efferveſcence, attended with many bubbles, which will riſe to a conſiderable heighth one over the other. Stir the liquor when the efferveſcence ceaſes, and you will ſee it begin again.

When no efferveſcence appears upon ſtirring the liquor, add a little more Cream of Tartar, and the ſame phenomena will be renewed. Go on thus till you have obtained the point of perfect ſaturation.

Then filter your liquor. If the Alkali you made uſe of was the Salt of Soda, evaporate your liquor quickly to a pellicle, and there will ſhoot in it cryſtals of nine ſides reſembling a coffin; the bottom part thereof being concave, and ſtreaked with a great many parallel lines; and this is *Saignette's Salt*. If you have employed any other Alkali but Soda, or the baſis of Sea-Salt, evaporate your liquor ſlowly to the conſiſtence of a ſyrup: let it ſtand quiet, and there will form in it cryſtals having the figure of flatted parallelopipeds; and this is the *Vegetable Salt*, or *Tartarized Tartar*.

OBSERVATIONS.

SEEING pure Abſorbent Earths are capable of neutralizing Cryſtal of Tartar, and converting it into Soluble Tartar, there is ſtill more reaſon to expect that Fixed Alkalis ſhould poſſeſs the ſame property, as they have a much greater affinity with Acids: and accordingly Cryſtal of Tartar always forms, with every ſpecies of theſe ſalts, a Neutral Salt which is a Soluble Tartar.

A Soluble Tartar, formed by the union of Cryſtal of Tartar with Tartar converted into an Alkali by fire, hath been long uſed in medicine as a gentle ſaponaceous purgative, known by the names of *Tartarized Tartar*, or the *Vegetable Salt*. But the Soluble Tartar, prepared by combining Cryſtal of Tartar with the Alkali of Soda, which, as we remarked before, is analogous to the baſis of Sea-ſalt and different from all other Alkalis, was not well known to Chymiſts till the year 1731, when M. Boulduc publiſhed the preparation in a Memoir printed with the Academy's collection for that year*.

Not but that it was very much uſed before that time: for it had been for ſeveral years in high reputation, and preſcribed inſtead of Tartarized Tartar, which became almoſt quite neglected. But M. Saignette, a Phyſician of Rochelle, who was the firſt inventor and vender of this Salt, did not publiſh the preparation of it, which he kept as a ſecret: and this probably contributed not a little to that great eſteem which this medicine had acquired; for men are naturally inclined to put a much greater value on ſecrets, than on what is univerſally known. He gave it the name of *Sal Polychreſtum*; and the publick called it alſo *Saignette's Salt*, and *Rochelle Salt*. Since the diſcoveries of M. Geoffroy and M. Boulduc were publiſhed, the method of preparing this Salt hath been no ſecret: it was deſcribed in Diſpenſatories, and every Apothecary hath made it ever ſince.

Saignette's Salt, as well as every other Soluble Tartar, melts when laid on live coals, boils up, emits ſmoke, and leaves a black charred matter behind. This reſemblance of Saignette's Salt to Tartarized Tartar, joined to the ſmell of the vapour which exhaled in burning it, and which is the ſame with that of Tartar, were the firſt notices that led M. Boulduc to ſuppoſe this Salt to be a Soluble Tartar. On examining the alkaline coal produced by the calcination, and comparing it with that left by Tartarized Tartar, he perceived there was ſome difference between them. At laſt his friend, M. Groſſe, having adviſed him, as he tells us in his Memoir, to combine Cryſtal of Tartar with the Salt of Soda, and to examine the new Salt that would reſult from their union, M. Boulduc immediately ſuſpected that it muſt produce a ſpecies of Soluble Tartar, which might poſſibly prove to be the Salt in queſtion. Nor was he miſtaken in his conjecture: for with theſe two ſaline ſubſtances he actually compoſed a Salt perfectly like Saignette's.

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* It could not be any longer concealed; for M. Geoffroy having made ſome experiments on the ſame ſubject, without knowing any thing of what M. Boulduc had done, likewiſe diſcovered it. See the Hiſtory of the Academy for 1731, p. 35.

Under the head of Borax we remarked that it contains an Alkali like the baſis of Sea-ſalt. This Alkali is not perfectly neutralized by the quieting Salt which is alſo contained in Borax: for its alkaline properties are ſo perceptible as to have led ſome Chymiſts to think that Borax was only an Alkali of a particular kind. This induced M. le Fevre, a Phyſician at Uzes, and one of the Academy's correſpondents, to combine Cryſtal of Tartar with Borax, and to examine the reſult. He communicated to the Academy his experiments on this ſubject; by which he found that the combination of theſe two ſaline matters forms a Soluble Tartar, but greatly different from Saignette's Salt; eſpecially in that it doth not cryſtallize, but remains in the form of a gummy matter, and retains all the Acidity natural to pure Cream or Cryſtal of Tartar: a circumſtance which is very remarkable.

Mr. Lemery had the curioſity to repeat M. le Fevre's experiment, and found that this ſingular Soluble Tartar had the properties aſcribed to it by the inventor. The proceſs he recommends for making the experiment with ſucceſs is as follows:

"Take four ounces of Cryſtal of Tartar finely "pulverized, and two ounces of Borax carefully "powdered, and put theſe two Salts into a flint-

" glaſs body. Pour on them two ounces of water, " and ſet the cucurbite in a ſand-bath. Warm it " with a gentle fire, and then increaſe the heat ſo " as to make the liquor boil for a quarter of an " hour; which will produce a perfect diſſolution of " the Cream of Tartar and Borax. After the diſ- " ſolution of theſe two Salts united together, the " liquor will remain clear and limpid, though the " boiling hath diſſipated a good deal of it. If the " liquor be ſtill further evaporated, the remainder " will have the conſiſtence of Honey, or Tur- " pentine: and, if the evaporation be carried ſtill " farther with a gentle heat, the matter remaining " will in colour reſemble the gum of a plumb-tree, " and yield to preſſure as that does; and, if it be " expoſed to the air in a damp place, it will grow " moiſt and run, almoſt like Salt of Tartar:" a new and ſingular property, which belongs neither to Borax nor to Cryſtal of Tartar, when they are not combined together.

All Soluble Tartars are eaſily decompounded, by means of a certain degree of heat. They yield in diſtillation the ſame principles as Tartar; and the Alkali that remains, when they are perfectly calcined, conſiſts of that which the Tartar naturally affords, and of the alkaline matter with which it was converted into a Neutral Salt.

Theſe Neutral Salts, reſulting from the union of Cryſtal of Tartar with any alkaline matter, are alſo decompounded by Acids, even by Vinegar, which nevertheleſs is an Oily Vegetable Acid, and conſequently of the ſame kind with Cryſtal of Tartar. The reaſon of this is that the Acid of Vinegar, though blunted by much phlegm and oil, muſt be conſidered as a free and pure Acid, when compared with Cryſtal of Tartar; which is ſtill more embaraſſed with heterogeneous matters, ſo as to be a ſemi-neutral Salt.

When Soluble Tartar is decompounded by an Acid, the Cryſtal of Tartar, which helped to conſtitute the Neutral Salt, is then wholly recovered. This ſaline matter, being ſeparated from that which rendered it ſoluble in water, ceaſes now to be ſo, and for that reaſon precipitates to the bottom of the liquor.

The Neutral Salts, reſulting from the decompoſition of Soluble Tartar by an Acid, differ according to the Acid made uſe of. From Saignette's Salt decompounded by the Vitriolic Acid Mr. Boulduc obtained a true Galuber's Salt, and a precipitate of Cryſtal of Tartar: and this he juſtly adduces as a demonſtrative proof that Saignette's Salt is no other than Cryſtal of Tartar neutralized by a Fixed Alkali analogous to the baſis of Sea-ſalt.

Though all Soluble Tartars may bedecompounded by Acids, as hath juſt been ſaid, yet they do not all forſake their baſes with equal facility. Meſſ. Duhamel and Groſſe found that, in this reſpect, they obſerve the following order, beginning with thoſe which afford the readieſt and moſt copious precipitate: viz. Soluble Tartar made 1. with Potaſh; 2. with Chalk; 3. with uncalcined Oiſter-ſhells; 4. with Stone-Lime; 5. with calcined Oiſter-ſhells; 6. with Salt of Tartar; 7. with Salt of Soda; 8. and laſtly, Tartar made ſoluble with Borax is not precipitated by diſtilled Vinegar.

It is not eaſy to account for this difference between Soluble Tartars. If the Salt of Soda were more alkaline than Salt of Tartar, and Borax more alkaline than the Salt of Soda, it might be conjectured that the more alkaline the matters are with which Cryſtal of Tartar is neutralized, the cloſer is the union it contracts with them; ſince it is plain from what hath been ſaid on this ſubject, that though Soluble Tartars, which have for their baſis Abſorbent Earths only, not converted into Lime, are more eaſily decompounded than thoſe which are rendered ſoluble by Limes; and theſe again more eaſily than thoſe which have a Fixed Alkali for their baſis. But, on the contrary, the Salt of Soda is leſs alkaline than Salt of Tartar, and Borax ſtill leſs than the Salt of Soda.

PROCESS III.

Cryſtal of Tartar combined with Iron. Chalybeated Tartar. Tincture of Steel with Tartar. Soluble Chalybeated Tartar.

MIX four ounces of Iron in filings with one pound of white Tartar finely pulverized. Boil the mixture in about twelve times as much water as you took of Tartar. When the ſaline part of the Tartar is diſſolved, filter the liquor boiling-hot through a flannel bag, and then ſet it in a cool place. In a very little time cryſtals of a ruſſet colour will ſhoot therein. Decant the liquor from theſe cryſtals; evaporate it to a pellicle, and ſet it again to cryſtallize. Go on in this manner till it will ſhoot no more. Collect all the Salt you have thus obtained, and keep it under the name of *Chalybeated Tartar*.

To make the Tincture of Steel with Tartar, mix together ſix ounces of clean Iron filings and one pound of white Tartar in powder. Put this mixture into a large iron kettle, and pour thereon as much rain-water as will moiſten it. Make a paſte of this matter, and leave it thus in a maſs for twenty four hours. Then pour on it twelve pounds of rain-water, and boil the whole for twelve hours at leaſt, ſtirring the mixture frequently, and adding from time to time ſome hot water, to ſupply the place of what evaporates. When you have thus boiled the liquor, let it ſtand quiet for ſome time, and then pour it off from the ſediment at bottom. Filter, and evaporate to the conſiſtence of a ſyrup; and you have the *Tincture of Mars with Tartar*. The Diſpenſatories generally order an ounce of rectified Spirit of Wine to be poured on this Tincture, in order to preſerve it, and to keep it from growing mouldy, as it is very apt to do.

Soluble Chalybeated Tartar is prepared by mixing four ounces of Tartarized Tartar with one pound of the Tincture of Mars with Tartar, and evaporating them together in an iron veſſel to dryneſs; after which it is kept in a well ſtopped phial to prevent its growing moiſt in the air.

OBSERVATIONS.

THE three preparations of this proceſs are medicines very well known and much uſed. There is even reaſon to think that thoſe, who firſt thought of combining Tartar in this manner with Iron, had it in their view to prepare compoſitions uſeful in medicine, rather than merely to produce new combinations for the improvement of Chymiſtry. Indeed, were we to conſider only the account here given of the manner in which theſe three compoſitions are made, we ſhould be inclined to think Cryſtal of Tartar incapable of diſſolving Iron ſo thoroughly and radically, that from the union of theſe two ſubſtances a Neutral Metallic Salt ſhould ariſe, a Tartar neutralized and made ſoluble by Iron. For it is very certain that the firſt of theſe preparations, which is called Chalybeated Tartar, is nothing but the ſaline part of Tartar diſſolved by boiling water, and then precipitated and cryſtallized along with particles of Iron; that are reduced, at moſt, into a ruſt or a *crocus* only, but have contracted no union with the Cryſtal of Tartar, which remains as Acid and as indiſſoluble after this preparation as before. Accordingly it is called only *Chalybeated Tartar*, and not *Soluble Chalybeated Tartar:* and, as this latter name hath been given only to the Tartarized Tincture of Mars compounded with Tartarized Tartar; that is, with Tartar rendered ſoluble by a Fixed Alkali, and not by Iron; there is reaſon to preſume, that the Tincture of Mars alone was not thought worthy of being called a Soluble Chalybeated Tartar; but that the name importing *Tartar rendered ſoluble by Mars* belonged to that Tincture only when compounded with a true Soluble Tartar.

It is neverthleſs very certain that the Tincture of Mars made with Tartar contains a true Soluble Chalybeated Tartar; that is, a Neutral Salt conſiſting of Cryſtal of Tartar united with Iron, and rendered ſoluble by that union. The long boiling neceſſary to prepare this Tincture gives the Acid of Tartar time to diſſolve the Iron radically, and to unite very cloſely therewith: but this is not the caſe in the preparation of Chalybeated Tartar; to make which the Tartar is boiled in water only as long as is neceſſary for the diſſolution of its ſaline parts; that is, about a quarter or half an hour; in which ſpace the Acid of the Tartar can ſcarce begin to act on the ſurface of the Iron: for Acids have not ſo quick an effect on metals as on Alkalis and Abſorbent Earths. Metallic ſubſtances, being vaſtly more compact, are not near ſo ſoon diſſolved by Acids, and eſpecially by Vegetable Acids weakened with heterogeneous matters, as the Acid of Tartar is.

I thought the diſſolution of Iron by Tartar a point of ſufficient importance to deſerve a little more attention than hath commonly been given to it; and for that reaſon reſolved to examine, and trace with care, the phenomena obſervable in this operation.

As the crude Tartar, employed in making the Tartarized Tincture of Mars, is replete with many oily and earthy parts, which cannot but obſtruct the diſſolution of the Iron, and prevent our ſeeing clearly how that diſſolution is carried on, I thought it better to make uſe of Cream or Cryſtals of Tartar, which, being pure and freed from all thoſe heterogeneous parts, diſſolve in boiling water without prejudicing its tranſparency.

I therefore pulverized Cream of Tartar, and diſſolved as much thereof in boiling water as it would take up. This ſolution I poured boiling hot into a matraſs, at the bottom of which I had laid ſome fine Iron wire cut into little pieces. I ſet the matraſs in a ſand-bath; and having heated it ſo as to make the liquor boil, I obſerved that the inſtant before it boiled the liquor began to act very perceptibly upon the Iron, in the ſame manner as other Acids act upon metallic ſubſtances; that is, there appeared on the ſurfaces of the little bits of Iron ſmall bubbles, which immediately roſe to the ſurface of the liquor, and ſucceeded each other ſo faſt, that they formed lines or jets ſeemingly continued from the ſurface of the Iron to the ſurface of the liquor, which little by little acquired a ſmall tinge of yellow.

When the liquor was heated ſo as to boil, the diſſolution ſtill went on, but much more briſkly, and the liquor acquired a deeper colour. After boiling about an hour, the liquor, which at firſt was very clear, became turbid, and of an opaque white; which made me think that ſome of the Cream of Tartar diſſolved therein began to precipitate.

I let the whole boil ſome time longer, and the white precipitate becoming more conſiderable, I reſolved to filter the liquor, which paſſed through clear and tinged with a greeniſh yellow. There remained on the filter a whitiſh ſediment, which I found to be true Cream of Tartar. The filtered liquor taſted much like a ſolution of copperas. I evaporated it in a glaſs baſon, ſet it in a ſand-heat, but no pellicle appeared; which made me conclude that it would produce no cryſtals: accordingly having taken ſome of it out of the baſon, when it was conſiderably reduced by evaporation, and ſet it in a cool place, no cryſtals ſhot in it.

The reſt of the liquor I evaporated to dryneſs: it left a blackiſh brown reſiduum, which had the ſame taſte with the liquor before evaporation, but much ſtronger. This reſiduum melts very readily in the mouth, without leaving on the tongue the leaſt gritty particle. Being expoſed very dry to the air, it grows moiſt, and runs into a liquor in a very little time. It diſſolves eaſily and readily in a very ſmall quantity of cold water. This ſolution being mixed with Fixed Alkalis, in various proportions, doth not grow turbid, or drop any precipitate; but with a decoction of galls it makes ink. Acids give it a much clearer colour, and at firſt produce no precipitation; but, in a quarter of an hour, there appears a precipitate much of the ſame colour with the ſolution. This precipitate is no other than Cream of Tartar, tinged of a ruſſet colour by the liquor, which grows turbid and a little whitiſh when the precipitate begins to form.

Theſe experiments, and the circumſtances attending them, will not allow us to doubt the truth of what I advanced concerning the Tincture of Mars made with Tartar; viz. that it is nothing but Cryſtal of Tartar by which Iron is diſſolved, and which is rendered ſoluble by that metal. We ſee at the very firſt that Cryſtal of Tartar acts upon Iron, juſt as other Acids do. Indeed this metallic ſolution is not precipitated by Alkalis: but we know that Alkalis poſſeſs the property of diſſolving Iron, eſpecially when the metal is previouſly divided by an Acid; ſo that there is reaſon to think this may be the caſe when an Alkali is mixed with our Soluble Chalybeated Tartar.

As this Soluble Tartar is a ſaponaceous and oily Salt, it is alſo poſſible that it may be diſſolved entirely by the Alkali, without ſuffering any decompoſition; eſpecially as Alkalis decompound Neutral Metallic Salts by means only of the ſtronger affinity which they have with the Acids, than with the Metals, of which thoſe Salts are compounded. Now, as our Soluble Chalybeated Tartar is compounded of that Metal which the Alkali diſſolves with the greateſt eaſe, and of that Acid with which it hath the leaſt affinity of any, it is very poſſible that it may not have a greater affinity with the Acid than with the metallic baſis of this Salt, and ſo be uncapable of decompounding it. However, as this Soluble Chalybeated Tartar makes a black liquor with a decoction of Galls, and as nothing but Iron diſſolved by an Acid hath that property, it may be ſafely concluded that this Salt really conſiſts of Iron diſſolved by the Acid of Tartar.

The precipitate which a ſolution of this Salt lets fall, on the addition of an Acid, is another proof that it conſiſts of theſe two principles: for this precipitate can be no other than the Tartarous Acid, which, being the weakeſt of all Acids, is ſeparated from the Iron by the Acid added to the ſolution; which Acid unites with the martial baſis, and forms another Neutral Metallic Salt, according to the Acid employed. Laſtly, the great ſolubility of the deſiccated reſiduum of the Tincture of Mars made with Tartar is a very ſtrong and deciſive proof that this reſiduum is no other than Iron diſſolved by the Acid of Tartar: for what elſe can it be? Nothing but Iron and Cryſtal of Tartar is made uſe of in the operation; and neither of theſe two ſubſtances ſingly is ſo ſoluble as this new body.

We know, moreover, that Cryſtal of Tartar, which itſelf is indiſſoluble, forms a Soluble Tartar when combined with pure Abſorbent Earths, though theſe matters be ſtill more indiſſolvable than it, or rather, are not ſoluble at all. Hence it is very natural to conclude that our reſiduum is a Tartar rendered ſoluble by Iron. This Chalybeated Tartar is even more ſoluble than any other ſort of Soluble Tartar; for it very readily grows moiſt in the air, and runs wholly into a liquid; on which account it is not ſuſceptible of cryſtallization.

I return to one of the circumſtances attending my experiment, which it is proper I ſhould account for; though I have hitherto only mentioned it, without more particular notice, that I might not break the connection between facts and the conſequences reſulting from them. The circumſtance I mean is the precipitation of the Cream of Tartar diſſolved in the liquor, which, I ſaid, happens when the ſaline ſolution hath boiled upon the Iron about an hour. This precipitation of the Cream of Tartar may be partly occaſioned by the evaporation of the water in which it is diſſolved: for the water having taken up, as was ſaid, as much Cream of Tartar as it was capable of diſſolving, when the quantity of water comes to be leſſened, a proportional quantity of Cream of Tartar muſt precipitate.

But ſome other cauſe muſt alſo contribute to produce this precipitation: for, as I boiled my liquor in a matraſs, the evaporation of the liquor could not be conſiderable, and yet the precipitate was very copious. Moreover, I repleniſhed the matraſs with much more water than was neceſſary to replace what had evaporated; yet I could not re-diſſolve the precipitated Cream of Tartar, nor even ſenſibly leſſen its quantity.

The true cauſe of this effect I take to be as follows. When the ſolution of Cream of Tartar hath boiled for ſome time upon the Iron, and diſſolved a certain quantity thereof, a proportional quantity of Soluble Chalybeated Tartar is formed. Now as this Salt is much more ſoluble in water than Cream of Tartar, and as water always takes up the more ſoluble Salts, preferably to the leſs ſoluble, it is not ſurpriſing that Cream of Tartar, being one of thoſe ſaline ſubſtances which diſſolve with the greateſt difficulty, ſhould on this occaſion ſeparate from the liquor, and precipitate; yielding its place to a Salt which hath a much greater affinity with water.

Hence it appears that to re-diſſolve the Cream of Tartar, and render it capable of continuing to diſſolve the Iron as efficaciouſly as before, it is not ſufficient that freſh water be added; but the ſolution of the Soluble Chalybeated Tartar already formed muſt be entirely decanted, and freſh water poured on the reſidue; and then this water, not being impregnated with any Soluble Chalybeated Tartar, will be capable of re-diſſolving the Cream of Tartar, and every thing will go on as at the beginning of the operation, till the Cream of Tartar come to precipitate again, for the ſame reaſon as before, and make a repetition of the ſame management neceſſary. The liquor is far from being ſaturated with Soluble Chalybeated Tartar, when the precipitation of the Cream of Tartar renders it neceſſary to decant it: ſo that the water muſt be often renewed, if you carry the operation to the utmoſt; and then all theſe ſolutions muſt be added together and evaporated either to dryneſs, if you deſire to have the Salt in a dry form, or to any other degree you think proper.

This method I followed at firſt: but as it is exceeding long and tedious, though perhaps the beſt and as I wanted to have a moderate quantity of Soluble Chalybeated Tartar, with leſs trouble and in leſs time, if poſſible, I reſolved to try whether or no Cream of Tartar, though ſeparated from the liquor and undiſſolved, were ſtill capable of acting on the Iron with ſuch efficacy as to diſſolve it. I therefore continued to boil the tartarous ſolution on the filings of Iron, notwithſtanding the precipitation of the Cream of Tartar, taking care only to add freſh water from time to time, as directed in the proceſs for the Tartarized Tincture of Mars, to replace what evaporated; and I obſerved that, in fact, the Cream of Tartar, though not perfectly diſſolved, but only divided and agitated by the motion of boiling, ſtill continued to act upon the Iron; ſo that the liquor, after boiling ſeven or eight hours, was ſo impregnated as to yield by evaporation a reaſonable quantity, in bulk, of Salt in a dry form.

PROCESS IV.

Cryſtal of Tartar combined with the reguline part of Antimony. Stibiated or Emetic Tartar.

PULVERIZE and mix together equal parts of the Glaſs and of the Liver of Antimony. Put this mixture, with the ſame quantity of pulverized Cream of Tartar, into a veſſel capable of containing as much water as will diſſolve the Cream of Tartar. Boil the whole for twelve hours, from time to time adding warm water, to replace what is diſſipated by evaporation. Having thus boiled your liquor, filter it while boiling hot; evaporate to dryneſs;

neſs; and you will have a ſaline matter which is *Emetic Tartar.*

OBSERVATIONS.

THE Glaſs and Liver of Antimony are no other, as was ſaid in its place, than the metallic earth of Antimony ſeparated from the redundant Sulphur of that mineral; but ſtill retaining ſuch a quantity of phlogiſton as to poſſeſs, excepting its metalline colour, nearly the ſame properties with Regulus of Antimony, and eſpecially its Emetic quality, and its ſolubility in Acids. Indeed theſe two preparations ſeem to have more of an Emetic quality than the Regulus itſelf, and therefore are employed preferably to all others in the preparation of Emetic Tartar.

It is not yet aſcertained in which of the principles of Antimony its Emetic virtue reſides. We are ſure however that it cannot be aſcribed to its earthy part: for the calx of Antimony, when entirely deprived of all phlogiſton, is not Emetic, nor even purgative; as is evident from the effects of Diaphoretic Antimony and the Pearly matter.

Some Authors think Antimony contains an Arſenical principle, to which they impute its Emetic quality: nor is their opinion altogether void of probability. For this arſenical part ſeems to be indicated by ſeveral of the properties of Antimony, and particularly by its affinities with other metallic ſubſtances, in which it very nearly reſembles Arſenic. But this doth not amount to a poſitive proof: for we can draw nothing but probable conjectures, at moſt, from ſuch analogies.

Other Chymiſts think the Emetic virtue of Antimony depends on the union of its metallic earth with its phlogiſton. This opinion ſeems to me much more probable than the other: for by only recombining a phlogiſton with the earth of Antimony deprived by calcination of all its Emetic virtue, that virtue is perfectly reſtored, and the Regulus thus revivified is no leſs Emetic than that which never underwent calcination.

However this be, it is certain that Cream of Tartar acquires an Emetic quality, not by barely uniting with one of the principles of Antimony, but by diſſolving entirely the reguline or ſemi-reguline part thereof; and that its Emetic quality is ſo much the ſtronger the more of that ſubſtance it hath diſſolved. This is the reſult of ſeveral experiments made on the ſubject by Mr. Geoffroy.

That gentleman collected ſeveral parcels of Emetic Tartar, having different degrees of ſtrength. "I "employed, ſays he, * an ounce of each of thoſe "Emetic Tartars: I rubbed them ſeparately with an "equal weight, or ſomething more, of a black flux "made of two parts of red Tartar and one part "of Nitre calcined together. Theſe mixtures I "put into different crucibles, formed like inverted cones: I kept them in a melting heat till "the Salts in fuſion ſunk, and appeared like a "ſmooth oil at the bottom of each crucible. I "then let the fire go out; broke the crucibles when "cold, and found the reſuſcitated Regulus in a maſs "at bottom.

"Out of one ounce of the weakeſt Emetic Tartars I obtained from thirty grains to one dram "eighteen grains of Regulus. From one ounce "of ſuch as were of a middling ſtrength I got one "dram and an half; and the moſt violent yielded "me two drams and ten grains.

"The power therefore of the ſtrongeſt Emetic "Tartars, continues he, depends on the quantity "of Regulus of Antimony diſſolved by the Cream "of Tartar, and the nearer the preparations of "Antimony, on which the ſolution of Cream of

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* Memoirs of the Academy for 1734. p. 421.

"Tartar is boiled, are to the form of a Regulus or "a Glaſs, the more violent is the Emetic Tartar; "becauſe the Vegetable Acid of the Tartar acts "then more immediately upon the Emetic part of "the Antimony, and diſſolves more of it."

Mr. Geoffroy found upon trial that Cream of Tartar, boiled for a due time on Crude Antimony, doth indeed diſſolve a little of the reguline part thereof; but that the quantity of Regulus diſſolved thereby is ſo very ſmall, that the Emetic Tartar produced is extremely weak. The groſs Sulphur hinders the Cream of Tartar from acting on the reguline part, in this caſe, with ſo much efficacy as when the Antimony is properly prepared by freeing it entirely from its redundant Sulphur.

Nothing can be added to what Mr. Geoffroy hath ſaid on this ſubject. His experiments are deciſive, and ſet the truth he intended to prove in the cleareſt light.

Mr. Hoffman affirms that Emetic Tartar loſes part of its virtue by being boiled too long. A very able Chymiſt goes ſo far as to ſay that Tartar ought not to boil above ſix or ſeven minutes with prepared Antimony; becauſe longer boiling deſtroys part of its Emetic quality. Can this ariſe from hence, that Cream of Tartar, after diſſolving a certain quantity of the reguline ſubſtance, ſeparates from it afterwards? Or is the Cream of Tartar itſelf decompoſed by too long boiling? This deſerves to be particularly enquired into, as well as the nature of the Metallic Salt which reſults from the union of the Acid of Tartar with the Regulus of Antimony.

Cryſtal of Tartar acts alſo on ſeveral other metallic ſubſtances, and particularly on Lead; with which it forms a Salt reſembling Tartarized Tartar in the figure of its cryſtals.

CHAP. V.

OF THE PRODUCT OF ACETOUS FERMENTATION.

PROCESS I.

Subſtances ſuſceptible of the Acetous Fermentation turned into Vinegar.

THE Wine, the Cyder, or the Malt-liquor, you intend to convert into Vinegar, being firſt thoroughly mixed with its lees, and with the Tartar it may have depoſited, put your liquor into a vat uſed before either for making or for holding Vinegar. This veſſel muſt not be quite full, and the external air muſt have acceſs to the liquor contained in it. Set it where the air may have a degree of warmth anſwering nearly to the twentieth degree above 0 in Mr. de Réaumur's Thermometer. Stir the liquor from time to time. There will ariſe in it a new fermentative motion, accompanied with heat: its vinous odour will gradually change, and turn to a ſour ſmell, which will become ſtronger and ſtronger till the fermentation be finiſhed and ceaſe of itſelf. Then ſtop your veſſel cloſe; the liquor it contains will be found converted into Vinegar.

OBSERVATIONS.

ALL ſubſtances that have undergone the ſpirituous fermentation are capable of being changed into an Acid by paſſing through this ſecond fermentation, or this ſecond ſtage of fermentation. Spirituous liquors, ſuch as Wine, Cyder, Beer, being expoſed to a hot air, grow ſour in a very ſhort time. Nay, theſe liquors, though kept with all poſſible care, in very cloſe veſſels, and in a cool place, degenerate at laſt, change their natures, and inſenſibly turn ſour. Thus the product of ſpirituous fermentation naturally and ſpontaneouſly degenerates to an Acid.

For this reaſon it is of great importance, in making Wine, or any other vinous liquor, to ſtop the fermentation entirely, if you deſire the Wine ſhould contain as much Spirit as poſſible. It is even more advantageous to check the fermentation a little before it comes to the heighth than afterwards: becauſe the fermentation, though ſlackened and in appearance totally ceaſed, ſtill continues in the veſſels; but in a manner ſo much the leſs perceptible as it proceeds more ſlowly. Thus thoſe liquors, in which the fermentation is not quite finiſhed, but checked, continue for ſome time to gain more Spirit; whereas, on the contrary, they degenerate and gradually turn ſour, if you let the ſpirituous fermentation go on till it be entirely finiſhed.

The production of the ſecond fermentation, which we are now to conſider, is an Acid of ſo much the greater ſtrength, the ſtronger and more generous the ſpirituous liquor, in which it is excited, originally was. The ſtrength of this Acid, commonly called *Vinegar*, depends likewiſe in a great meaſure on the methods uſed in fermenting the vinous liquor, in order to convert it into Vinegar: for if it be fermented in broad, flat veſſels, and left to grow ſour of itſelf, the ſpirituous parts will be diſſipated, and the liquor be ſour indeed, but vapid and effete.

The Vinegar-makers, to increaſe the ſtrength of their Vinegar, uſe certain methods of which they make a myſtery, keeping them very ſecret. However, Mr. Boerhaave gives us, from ſome Authors, the following deſcription of a proceſs for making Vinegar:

“ Take two large oaken Vats or Hogſheads, and in each of theſe place a wooden grate or hurdle, at the diſtance of a foot from the bottom. Set the veſſel upright, and on the grates place a moderately cloſe layer of green twigs, or freſh cuttings of the vine. Then fill up the veſſel with the foot ſtalks of grapes, commonly called the *Rape*, to within a foot of the top of the veſſel, which muſt be left quite open.

“ Having thus prepared the two veſſels, pour into them the Wine to be converted into Vinegar, ſo as to fill one of them quite up, and the other but half full. Leave them thus for twenty four hours, and then fill up the half-filled veſſel with liquor from that which is quite full, and which will now in its turn be left only half full. Four and twenty hours afterwards repeat the ſame operation, and thus go on, keeping the veſſels alternately full and half full during every twenty four hours, till the Vinegar be made. On the ſecond or third day there will ariſe, in the half-filled veſſel, a fermentative motion, accompanied with a ſenſible heat, which will gradually increaſe from day to day. On the contrary, the fermenting motion is almoſt imperceptible in the full veſſel; and as the two veſſels are alternately full and half full, the fermentation is by that means, in ſome meaſure, interrupted, and is only renewed every other day, in each veſſel.

“ When this motion appears to be entirely ceaſed, even in the half-filled veſſel, it is a ſign that the fermentation is finiſhed; and therefore the vinegar is then to be put into common caſks cloſe ſtopped, and kept in a cool place.

“ A greater or leſs degree of warmth accelerates or checks this, as well as the ſpirituous fermenta-

"tion. In France it is finiſhed in about fifteen "days, during the ſummer; but if the heat of "the air be very great, and exceed the twenty "fifth degree of Mr. de Réaumur's Thermometer, "the half-filled veſſel muſt be filled up every "twelve hours; becauſe if the fermentation be not "ſo checked in that time, it will become ſo violent, "and the liquor will be ſo heated, that many "of the ſpirituous parts, on which the ſtrength of "the Vinegar depends, will be diſſipated; ſo that "nothing will remain, after the fermentation, "but a vapid waſh, ſour indeed, but effete. The "better to prevent the diſſipation of the ſpirituous "parts, it is a proper and uſual precaution to cloſe "the mouth of the half-filled veſſel, in which the "liquor ferments, with a cover made alſo of oak "wood. As to the full veſſel, it is always left "open, that the air may act freely on the liquor "it contains: for it is not liable to the ſame inconveniences, "becauſe it ferments but very ſlowly."

The vine-cuttings and grape-ſtalks, which the Vinegar-makers put into their veſſels, ſerve to increaſe the ſtrength of the liquor. Theſe matters contain a very manifeſt and perceptible Acid. They alſo ſerve as a ferment; that is, they diſpoſe the Wine to become eager more expeditiouſly and more vigorouſly. They are the better and the more efficacious for having been once uſed, becauſe they are thereby thoroughly drenched with the fermented Acid: and therefore the Vinegar-makers lay them by for preparing other Vinegar, after waſhing them nimbly in running water, in order to free them from a viſcid oily matter, which ſettles on them during the fermentation. This matter muſt by all means be removed; becauſe it is diſpoſed to grow mouldy and rot; ſo that it cannot but be prejudicial to any liquor in which you put it.

As the Acetous fermentation differs from the Spirituous in its production, ſo it doth in many circumſtances attending it. 1. Motion and agitation are not prejudicial to the Acetous fermentation, as they are to the Spirituous; on the contrary, moderate ſtirring, provided it be not continual, is of ſervice to it. 2. This fermentation is accompanied with remarkable heat; whereas the warmth of the ſpirituous fermentation is ſcarce ſenſible. 3. I do not believe there ever was an inſtance of the vapour that riſes from a liquor in Acetous fermentation proving noxious, and producing either diſorders or ſudden death, as the vapour of fermenting Wine doth. 4. Vinegar depoſites a viſcid oily matter, as hath juſt been obſerved, very different from the Lees and Tartar of Wine. Vinegar never depoſites any Tartar; even though new Wine, that hath not yet depoſited its Tartar, ſhould be uſed in making it.

The following proceſſes will give us occaſion to treat of the nature of Vinegar, and the principles of which it conſiſts.

PROCESS II.

To concentrate Vinegar by Froſt.

EXPOSE to the air, in froſty weather, the Vinegar you deſire to concentrate. Icicles will form in it; but the whole liquor will not freeze. Take out thoſe icicles: and if you deſire a further concentration of your Vinegar by this method, the liquor which did not freeze the firſt time muſt be expoſed to a ſtronger froſt. More icicles will form therein, which muſt likewiſe be ſeparated, and kept by themſelves. The liquor which doth not freeze this ſecond time will be a very ſtrong concentrated Vinegar.

OBSER-

OBSERVATIONS.

LIQUORS, replete with an Acid, freeze with much more difficulty than pure water. Thus, if a very aqueous acid liquor be expoſed to froſt, ſome of the water in the liquor will preſently freeze; while the reſt, being rendered more acid by the ſeparation of the frozen phlegm, will remain fluid, and reſiſt the degree of cold which freezes water. Now Vinegar, being an acid liquor containing much water, may therefore be highly concentrated by freezing its phlegm in this manner; and the more icicles you get from it, the ſtronger and more active will the remaining Vinegar be.

Mr. Stahl was the firſt, I believe, who thus made uſe of congelation for procuring a very ſtrong Acid of Vinegar. Mr. Geoffroy hath ſince taken the ſame method. A curious and circumſtantial account of his experiments on this ſubject are printed in the Memoirs of the Academy for 1739.

As it was exceſſive cold in the winter of that year, Mr. Geoffroy took the opportunity of expoſing to the froſt ſeveral Vinegars of different ſtrengths; and he determined the degree of Acidity in each, both before and after their concentration, in order to compare them, and diſcover how much ſtronger each Vinegar was rendered by the freezing of the aqueous part. To determine the ſtrength of the Vinegars, he made uſe of the method pointed out by Mr. Homberg and Mr. Stahl. This method conſiſts in combining, to the exact point of ſaturation, a certain quantity of Vinegar with well dried Salt of Tartar. The more Salt of Tartar is required to abſorb and perfectly neutralize the Vinegar, the ſtronger it muſt be reckoned; becauſe the quantity of Alkali neceſſary to conſtitute a Neutral Salt is always proportioned to the quantity of Acid in that Salt.

One of the Vinegars employed in Mr. Geoffroy's experiments, two drams of which were entirely abſorbed by ſix grains of Salt of Tartar, having been concentrated by once freezing, and thereby reduced from eighteen quarts to ſix, he found it ſo increaſed in ſtrength that two drams thereof required twenty four grains of Salt of Tartar to abſorb them.

The firſt icicles that ſeparate from Vinegar in this proceſs are perfectly clear, and as inſipid as water. As the Vinegar becomes more concentrated, the plates of ice becoming thinner, more ſpungy, and flaky like ſnow, retain between them ſome portion of the Acid; and it is proper to begin to ſave them as ſoon as they appear to be ſenſibly acid. Mr. Geoffroy carried the concentration of Vinegar as far as the cold of that winter 1739 would allow him; and eight quarts of Vinegar, already concentrated by froſt in the preceding years, being reduced to two quarts and a half by the froſt of the 19th of January, the coldeſt day of that year, was found to be ſo ſtrong that two drams thereof required forty eight grains of Salt of Tartar to abſorb them. The icicles of this Vinegar, being thawed, retained ſo much ſtrength as to require thirteen grains of the Salt of Tartar to abſorb them.

Vinegar ſuffers no decompoſition by the congelation of its phlegm, and the conſequent concentration of its Acid. What is left ſtill contains all the principles of which Vinegar conſiſts. Its principles are only brought nearer together, and into a ſmaller compaſs: and for this reaſon it grows the thicker, the more it is concentrated. When therefore you deſire to concentrate the Acid of Vinegar, and at the ſame time to purify it, that is, to free it from ſome of its oil and earth, you muſt have recourſe to diſtillation.

Wine, as well as Vinegar, may be concentrated by freezing. Mr. Stahl expoſed ſeveral ſorts of

Wine to the froſt, and by that means ſeparated from them about two thirds, or three quarters, of almoſt pure phlegm. The remainders of the Wines ſo concentrated were of a ſomewhat thickiſh conſiſtence. They were very ſtrong, and kept for ſeveral years without altering, in places where the free acceſs of the air, alternately cold and hot according to the ſeaſons, would have ſoured or ſpoiled any other kind of Wine in the ſpace of a few weeks.

Wine thus concentrated by freezing is not thereby decompoſed, any more than Vinegar: it is only dephlegmated. By the addition of as much water as was ſeparated from it, you may reſtore it to its former condition; in which reſpect it differs greatly from the reſidue of Wine whoſe ſpirituous part, with a proportion of its phlegm, hath been drawn off by diſtillation: for though you mix that reſidue again with the principles you ſeparated from it, you can never make Wine of it again; the ſpirituous part being no longer in a capacity to combine with the other principles of the Wine, in the ſame manner as before that ſeparation. And this ſhews that heat, beſides ſeparating the moſt volatile parts, produces moreover a conſiderable change in the diſpoſition of thoſe which did not riſe in the firſt diſtillation.

Since the above experiments were made by Meſſ. Stahl and Geoffroy, concentration by freezing is pretty frequently practiſed in laboratories; but on Vinegar only, ſeldom on Wine: becauſe, when Vinegar is thus concentrated, a much ſtronger Acid is more eaſily and more expeditiouſly obtained from it, as will be ſhewn in the following proceſs; whereas the diſtillation, as well as the quality, of Spirit of Wine is much the ſame, whether the Wine it is obtained from be concentrated or no. The reaſon of this difference is, that Spirit of Wine, being very light, riſes in diſtillation before the phlegm; whereas the Acid of Vinegar, being much more ponderous, riſes only at the ſame time with the aqueous part, or even after it.

PROCESS III.

Vinegar analyzed by Diſtillation.

INTO a glaſs or ſtone cucurbite put the Vinegar to be diſtilled; fit to it a glaſs head; place your alembic in the ſand-bath of a diſtilling furnace, and lute on a receiver. Apply a very gentle heat at firſt. A clear, limpid, light liquor will riſe, and fall in diſtinct drops, like water, from the noſe of the alembic.

Continue diſtilling this firſt liquor, till the vinegar contained in the cucurbite be diminiſhed about a fourth part. Then ſhift your receiver, and increaſe the fire a little. A clear liquor will ſtill come over, but heavier and more acid than the former. Diſtill in this manner till you have drawn off into your ſecond receiver two thirds of the liquor that was left in the cucurbite.

A thick matter will now remain at the bottom of the ſtill: put it into a retort; lute on a receiver; ſet your retort in a reverberating furnace, and diſtill with degrees of fire. There will come over a limpid liquor, very acid and ſharp, yet ponderous, and requiring a great degree of fire to raiſe it; on which account it makes the receiver very hot. It hath a ſtrong empyreumatic ſmell. When the diſtillation begins to ſlacken, increaſe your fire. There will riſe an Oil of a fetid, quick ſmell. At laſt, when nothing more will riſe with the ſtrongeſt fire, break the retort, and in it you will find a black charred matter: burn it, and from the aſhes lixiviated with water you will obtain a Fixed Alkali.

OBSERVATIONS.

NONE of the liquors that come over in this operation, before the laſt fetid Oil, ſeem to have any other properties than thoſe of an oily Acid; none of them is inflammable, none of them reſembles Spirit of Wine; but all of them being thrown into the fire extinguiſh it. Mr. Boerhaave however takes notice that a Chymiſt, named Vigani, affirms the firſt portion of the liquor which riſes in the diſtillation of Vinegar to be inflammable, and no other than Spirit of Wine. Mr. Boerhaave ſuſpected that this might happen from Vigani's having diſtilled Vinegar too newly made; and found upon trial that Vinegar, being diſtilled ſoon after it was made, yielded at firſt in diſtillation a certain quantity of an Ardent Spirit; but that the ſame thing did not happen in the diſtillation of old Vinegar. And this proves that fermentation hath the ſame effect on Vinegar as on Wine; that is, that though the fermentation which produces theſe liquors ſeems to be over in a certain time, when the violent inteſtine commotion ceaſes, yet it ſtill continues in the veſſels for a conſiderable time after, though it be imperceptible. Thus, the portion of Ardent Spirit, obtained from ſome Vinegars, comes from a ſmall quantity of Wine which ſtill remains unchanged in theſe Vinegars, not having had time enough to turn ſour. For it is certain, from the experiments of all other Chymiſts as well as Mr. Boerhaave, that Vinegar, when old enough, yields no Ardent Spirit in diſtillation.

But though old and well made Vinegar yields no Ardent Spirit in diſtillation, we cannot thence conclude that it contains none. On the contrary, there are experiments which demonſtrate that ſome of the Ar-

Ardent Spirit, which was in the Wine before it was turned into Vinegar, ſtill remains; but probably ſo combined and blended with the acid part, that it cannot be ſeparated and rendered perceptible but by peculiar proceſſes.

Mr. Geoffroy obtained an Ardent Spirit from Vinegar, by diſtilling it as ſoon as it was concentrated by freezing. “ This ſpirit, ſays he *, is “ the firſt liquor that riſes. At firſt it hath only “ the ſame degree of inflammability as brandy; “ but, when re-diſtilled in the *balneum mariæ*, it “ fires gun-powder, like the beſt rectified Spirit “ of Wine: with this difference that our Spirit is “ impregnated with an oil of an acrid taſte and “ empyreumatic ſmell, which makes it yellow, “ and imparts its odour to it. This Spirit, at “ leaſt that which comes over firſt, retains none of “ the Acid of the Vinegar; ſeeing it neither changes “ the tincture of violets, nor efferveſces with Salt “ of Tartar.”

Mr. Geoffroy obſerves, that, if Vinegar concentrated by freezing be afterwards kept for ſeveral years, no Ardent Spirit will then be obtained from it by diſtillation. And this confirms what we ſaid of unconcentrated Vinegar, and gives reaſon to think that the Ardent Spirit obtained from Vinegar, either by diſtilling it after concentration by freezing, or by other proceſſes of which we ſhall treat in the ſequel, is foreign to the Vinegar, and is only found therein, as was ſaid above, becauſe Vinegar contains a certain quantity of Wine which hath not altered its nature. For the Spirit of Wine we obtain from Vinegar doth not hinder our obtaining from it a great deal of Acid, which being more ponderous riſes after it. Mr. Geoffroy gives the following account of the ſequel of his analyſis of Vinegar by diſtillation.

“ Con-

* Memoirs of the Academy for 1739.

"Continuing to diſtill in a *balneum mariæ* the "concentrated Vinegar, of which I had employed "four pounds two ounces, there was left, after the "diſtillation, a reſiduum of fourteen ounces; "which could not riſe, becauſe it was too thick. "I found it covered with a ſaline cruſt, which is "the true Eſſential Salt of Vinegar, and not of the "ſame nature with Tartar: for Tartar of Wine "is ſcentleſs; whereas this Salt of Vinegar hath "a pungent ſmell, being the Acid of Tartar ſub-"tilized by its union with the Sulphureous parts. "If a ſand-bath be now uſed, inſtead of the *balneum* "*mariæ*, to carry on the diſtillation without burning "the matter, part of this Salt will be reſolved, and "yield the laſt Acid Spirit, which is the ſtrongeſt "that can be obtained.

"After I had by a ſand-heat extracted all the "Acid Spirit that the ſeveral reſiduums put toge-"ther would yield, I found at the bottom of the "cucurbite a brown maſs, of the conſiſtence of a "pretty ſolid extract. Of this I put into a retort "two pounds, together with ſix pounds of ſand "well waſhed and very dry; and, applying a gra-"duated heat, I firſt obtained ſix ounces of an "Acid Spirit, that ſmelt very ſtrong of the empy-"reuma, and was a little coloured with ſome portion "of oil: ſeven ounces of Spirit, having a volatile "urinous ſmell, came over next: at laſt, the "white vapours appeared more and more denſe. "A volatile concrete Salt adhered to the ſides of "the ballon, and I found four ounces of a thick "fetid Oil floating on the Spirit. The concrete "volatile Salt when collected weighed two drams. "The black matter remaining in the bottom of the "retort, being calcined and lixiviated, yielded a "fat alkaline Salt, which it is almoſt impoſſible to "dry."

I have given this account of Mr. Geoffroy's analyſis of Vinegar at length, only becauſe it differs in ſeveral reſpects from that deſcribed in the proceſs, which is Mr. Boerhaave's, as well as from thoſe delivered by ſeveral other Authors, who make no mention either of the ſaline matter, which Mr. Geoffroy found on the reſiduum of Vinegar after its firſt diſtillation in the *balneum mariæ*, or of the volatile urinous Spirit and Salt, which he obtained from that reſiduum.

Theſe differences may ariſe either from the manner of diſtilling the Vinegar, or from Mr. Geoffroy's Vinegar having been concentrated by freezing, or rather from the quantity, and, above all, from the age of the Vinegar examined by thoſe different Chymiſts.

The diſtillation of Vinegar ſerves not only to ſeparate its Acid from a conſiderable quantity of earth and oily parts with which it is entangled, but alſo to dephlegmate and concentrate it. Yet Mr. Lemeri affirms that Vinegar is not diſtilled with a view to dephlegmate it. He condemns the common method of throwing away the firſt runnings as uſeleſs phlegm, and ſaving only what comes off afterwards; having, he ſays, obſerved, that the phlegm of Vinegar cannot be abſtracted, like that of many other acid liquors, and that what comes over firſt is almoſt as ſharp as what riſes afterwards, be the fire applied at firſt ever ſo ſmall.

There is reaſon to think that Mr. Lemeri did not carefully enough examine the ſtrength of the Spirit of Vinegar, at the different ſtages of his diſtillation: for Mr. Geoffroy, in the Memoir above cited, gives an account of a diſtillation of Vinegar, the product whereof he examined with care, having for that purpoſe divided it into five different portions: and his experiments put it beyond all doubt that the firſt portions of Spirit of Vinegar are far from being ſo acid as the laſt. This Vinegar was ſo ſtrong before diſtillation, that it required ſix grains of Salt of Tartar to abſorb two drams of it. Two drams of the firſt portion of his Spirit were abſorbed by three grains only of Salt of Tartar: the Acid of the ſecond portion took five grains to abſorb it. (Each experiment was made with two drams of Vinegar.) The third portion was abſorbed by ten grains; the fourth by thirteen, and the fifth took no leſs than nineteen: which proves that Vinegar, like moſt other Acids, may be concentrated by diſtilling off the moſt aqueous part, which is lighter than the Acid.

There are therefore two ways of concentrating Vinegar, and ſeparating its moſt acid part, namely diſtillation and congelation. Theſe two methods may be ſucceſſively applied to the ſame Vinegar, and a very powerful Acid obtained by their concurrence. Mr. Geoffroy having expoſed to the froſt, on the 19th of January 1739, the laſt ruſſet coloured liquor drawn from the reſiduum of diſtilled Vinegar, found it ſo concentrated thereby, that it required ſixty grains of Salt of Tartar to abſorb two drams of it.

CHAP.

CHAP. VI.

THE ACID OF VINEGAR COMBINED WITH DIFFERENT SUBSTANCES.

PROCESS I.

The Acid of Vinegar combined with alkaline ſubſtances. Foliated Salt of Tartar, or Regenerated Tartar. Decompoſition of that Salt.

INTO a glaſs cucurbite put ſome very pure and well dried Salt of Tartar; and pour on it ſome good diſtilled Vinegar, by little and little at a time. An efferveſcence will ariſe. Pour on more Vinegar, till you attain the point of ſaturation. Then fit a head to the cucurbite; ſet it in a ſand-bath; and having luted on a receiver, diſtill with a gentle heat, and very ſlowly, till nothing remain but a dry matter. On this reſiduum drop a little of the ſame Vinegar; and if any efferveſcence appears, add more Vinegar till you attain the point of ſaturation, and diſtill again as before. If you obſerve no efferveſcence, the operation was rightly performed.

OBSERVATIONS.

IT is not eaſy to hit the exact point of ſaturation in preparing this Neutral Salt; becauſe the oily parts, with which the Acid of Vinegar is loaded, hinder it from acting ſo briſkly and readily as it would do, if it were as pure as the Mineral Acids: and for this reaſon it often happens, that, when we have nearly attained the point of ſaturation, the addition of an Acid makes no ſenſible efferveſcence, though the Al-

Alkali be not yet entirely ſaturated; which deceives the operator, and makes him conclude erroneouſly that he hath attained the true point of ſaturation.

But he eaſily perceives his miſtake, when, after having ſeparated from this ſaline compound all its ſuperfluous moiſture by diſtillation, he drops freſh Vinegar upon it: for then the Salts being more concentrated, and conſequently more active, produce an effervefcence, which would not have been ſenſible if this laſt portion of Acid, inſtead of coming into immediate contact with the dried Alkali, could not have mixed therewith till diffuſed through, and in a manner ſuffocated by, that phlegm from which the Acid of the Vinegar before neutralized was gradually ſeparated by its combining with the Alkali; that phlegm keeping in ſolution both the Neutral Salt already formed and the Alkali not yet ſaturated. And for this reaſon it is neceſſary to try, after the firſt deſiccation of this Salt, which is called *Regenerated Tartar*, whether or no the juſt point of ſaturation hath been attained.

It may alſo happen, that, though the point of ſaturation was exactly hit at firſt, this compound Salt ſhall nevertheleſs, after deſiccation, effervefce with freſh Vinegar, and therefore not be in a perfectly neutral ſtate at that time. In this caſe the Salt muſt have been dried by too violent a fire, and partly decompounded by an exceſs of heat carrying off ſome of the Acid, which doth not adhere very ſtrongly to the Alkali. This is one of the reaſons why it is neceſſary that Regenerated Tartar be deſiccated with a very gentle heat.

From what hath been ſaid, concerning the deſiccation of this Neutral Salt, it is plain that the uſe of it is only to free the Salt from the great quantity of ſuperfluous moiſture wherein it is diſſolved: which proves that the Acid of Vinegar, like all other Acids diſſolved in much water, is ſeparated from moſt of this redundant phlegm by being combined with a Fixed Alkali. And hence we muſt conclude that the Acid of Vinegar, contained in Regenerated Tartar deſiccated, is vaſtly ſtronger and more concentrated than it was before: and accordingly Mr. Geoffroy, having decompounded this Salt, by the means of concentrated Oil of Vitriol, obtained a Spirit of Vinegar in white vapours, which was very volatile and very ſtrong, but perhaps ſomewhat depraved with a taint of the Vitriolic Acid.

Though the Acid of Vinegar is freed, by combining with a Fixed Alkali, from a great quantity of ſuperfluous phlegm, as was ſhewn above; yet the oily parts with which it is entangled ſtill cleave to it: theſe parts are not ſeparated from it by its converſion into a Neutral Salt, but, without quitting it, combine alſo with the Fixed Alkali; and this gives Regenerated Tartar a ſaponaceous quality, and ſeveral other peculiar properties.

Regenerated Tartar, when dried, is of a brown colour. It is ſemi-volatile; melts with a very gentle heat, and then reſembles an unctuous liquor; which indicates its containing an Oil: when caſt upon live coals, it flames; and, when diſtilled with a ſtrong heat, yields an actual Oil; all which evidently proves the exiſtence of that Oil.

This Salt is ſoluble in Spirit of Wine; a quality which it probably owes alſo to its Oil. It requires about ſix parts of Spirit of Wine to diſſolve it; and the diſſolution ſucceeds very well in a matraſs, with the help of a gentle warmth. If the Spirit of Wine be abſtracted from this ſolution, by diſtilling with a ſmall fire, it remains at the bottom of the cucurbite, in the form of a dry ſubſtance compoſed of leaves lying one upon another; which hath procured it the name of *Terra Foliata Tartari*, or *Foliated Salt of Tartar*.

It is not abſolutely neceſſary that Regenerated Tartar be diſſolved in Spirit of Wine to make the Foliated Salt: for it may be procured in this form only by evaporating the water in which it is diſſolved. But the operation ſucceeds better with Spirit of Wine; probably becauſe the ſucceſs thereof depends on uſing an exceeding gentle warmth: now Spirit of Wine evaporates with much leſs heat than water.

Regenerated Tartar may alſo be cryſtallized. If you deſire to have it in this form, combine the Acid with the Alkali to the point of ſaturation; evaporate the liquor ſlowly to the conſiſtence of a ſyrop, and ſet it in a cool place; where it will ſhoot into cluſters of cryſtals lying one upon another like feathers.

Vinegar perfectly diſſolves abſorbent matters alſo, and particularly thoſe of the animal kingdom; ſuch as Corals, Crabs-eyes, Pearls, &c. In order to a diſſolution of ſuch matters, you muſt pulverize them, put them into a matraſs, and pour on them Spirit of Vinegar to the depth of four fingers breadth: an efferveſcence will ariſe: when that is over, ſet the mixture to digeſt two or three days in a ſand-bath; then decant the liquor, filter it, and evaporate it to dryneſs with a very gentle heat. The matter which remains is called *Salt of Coral, of Pearls, of Crabs-eyes, &c.* according to the ſubſtances diſſolved. If, inſtead of evaporating the liquor, a Fixed Alkali be mixed therewith, the abſorbent matter, that was diſſolved by the Acid, will precipitate in the form of a white powder, which is called the *Magiſtery of Coral, of Pearls, &c.*

PROCESS II.

The Acid of Vinegar combined with Copper. Verdegris. Cryſtals of Copper. This combination decompounded. Spirit of Verdegris.

INTO a large matraſs put Verdegris in powder. Pour on it diſtilled Vinegar to the depth of four fingers breadth. Set the matraſs in a moderate ſand-heat, and leave the whole in digeſtion, ſhaking it from time to time. The Vinegar will acquire a very deep blue-green colour. When the liquor is ſufficiently coloured, pour it off by inclination. Put ſome freſh Vinegar into the matraſs; digeſt as before; and decant the liquor again when it is ſufficiently coloured. Proceed in this manner till the Vinegar will extract no more colour. There will remain in the matraſs a conſiderable quantity of undiſſolved matter. The Vinegar thus impregnated with Verdegris is called *Tincture of Copper.*

Mix theſe ſeveral Tinctures, and evaporate them with a gentle heat to a pellicle. Then ſet the liquor in a cool place: in the ſpace of a few days a great many cryſtals of a moſt beautiful green colour will ſhoot therein, and ſtick to the ſides of the veſſel. Pour off the liquor from the cryſtals; evaporate it again to a pellicle, and ſet it by to cryſtallize. Continue theſe evaporations and cryſtallizations, till no more cryſtals will ſhoot in the liquor. Theſe are called *Cryſtals of Copper*, and are uſed in painting. To this combination of the Acid of Vinegar with Copper the painters and dealers have given them the title of *Diſtilled Verdegris.*

OBSERVATIONS.

VERDEGRIS is prepared at Montpellier. To make it they take very clean plates of Copper, which they lay, one over another, with huſks of grapes be-

between, and after a certain time take them out. Their ſurfaces are then covered all over with a very beautiful green cruſt, which is *Verdegris*. This Verdegris is nothing but Copper corroded by the Acid of Tartar, analogous to the Acid of Vinegar, which abounds in the Wines of Languedoc, and eſpecially in the rape, huſks, and ſtones of grapes that have a very auſtere taſte. Verdegris is a ſort of ruſt of Copper; or Copper corroded and opened by the Acid of Wine, but not yet converted entirely into a Neutral Salt: for it is not ſoluble in water, nor does it cryſtallize. This ariſes from its not being united with a ſufficient quantity of Acid. The deſign of the operation here deſcribed is to furniſh the Verdegris with the quantity of Acid requiſite to make it a true Metallic Salt; for which purpoſe diſtilled Vinegar is very fit.

Cryſtals of Copper may be obtained, without employing Verdegris, by making uſe of Copper itſelf diſſolved by the Acid of Vinegar, according to the method practiſed with reſpect to Lead, as ſhall be ſhewn hereafter. But Verdegris is generally uſed, becauſe it diſſolves ſooneſt; it being a Copper already half-diſſolved by an Acid correſpondent to that of Vinegar.

Cryſtals of Copper are decompounded by the action of fire alone, without any additament; becauſe the Acid of Vinegar adheres but looſely to Copper. In order to decompound this Salt and extract its Acid, it muſt be put into a retort, and diſtilled in a reverbatory furnace with degrees of fire. An inſipid phlegm riſes firſt, which is the water retained by the Salt in cryſtallizing. This phlegm is ſucceeded by an acid liquor, which riſes in the form of white vapours that fill the receiver. Towards the end of the diſtillation the fire muſt be violently urged, in order to raiſe the ſtrongeſt and moſt fixed Acid. At laſt there remains in the retort a black matter, which is nothing but Copper, that may be reduced by melting it in a crucible with one part of Salt-petre and two parts of Tartar. A ſimilar Acid, but more oily, and in a much ſmaller quantity, may be obtained from Verdegris by diſtillation.

The Acid, which in this diſtillation comes over after the firſt phlegm, is an exceeding ſtrong and concentrated Vinegar. It is known by the title of *Spirit of Verdegris*. Zwelfer, and after him M. le Fevre in his Chymiſtry, beſtows extraordinary praiſes on this Spirit; pretending that it will make the Salt of Coral, and others of the ſame kind, without loſing any of its virtue, or ceaſing to be acid; ſo as to remain ſtill capable of performing other operations of the ſame nature. But Mr. Boerhaave and Mr. Lemeir poſitively deny the fact; and with good reaſon, having formed their judgments on their own experiments.

Yet I can hardly think both Zwelfer and le Fevre would have affirmed a thing of this nature in ſuch a poſitive and confident manner, if they had been convinced in their minds that it was falſe. We muſt ſuppoſe that thoſe Chymiſts examined the matter with too little attention, and were miſled by ſome fallacious appearance. Probably they may have compared this concentrated Vinegar with common diſtilled Vinegar; they may have put to their Coral an equal doſe thereof; and, after ſaturation, they may have diſtilled off the ſuperfluous liquor, which may have effervеſced with freſh Coral and diſſolved it. Surpriſed at this effect they may have imagined that their Acid had loſt none of its ſtrength, and that it had the virtue of converting into Salt any quantity of Coral, or ſuch other matters, without any prejudice to its Acidity. A raſh concluſion: which certainly they never would have made, if they had carried the experiment far enough; if they had diſſolved a third or a fourth quantity of Coral in their Vinegar: for they would have been thereby convinced that the Spirit of Verdegris, like all other acid Spirits, depoſites and leaves its Acid in abſorbent matters; and that if the liquor, which they drew off by diſtillation from their firſt Salt of Coral, was ſtill acid, and capable of diſſolving freſh Coral, nothing could be inferred from thence but that Spirit of Verdegris is an exceedingly concentrated Vinegar, which, in the ſame quantity of liquor, contains much more Acid than the ſtrongeſt diſtilled Vinegar prepared in the common way; that therefore a much ſmaller doſe thereof is required to convert a given quantity of Coral into Salt; and that the liquor, which they diſtilled from their firſt Salt, ſtill retained ſome of its virtue, only becauſe it was replete with much more Acid than could be neutralized by the Coral. But a love of the marvellous ſo prepoſſeſſes the mind of man, that it often hinders him from perceiving the moſt obvious things. This is the fault of all the ancient Chymiſts in general; and I believe the only reaſon why we find their books ſtuffed with ſo many unſucceeding experiments was, that their heated imaginations frequently repreſented things to them otherwiſe than they really were.

PROCESS III.

The Acid of Vinegar combined with Lead. Ceruſe. Salt or Sugar of Lead. This combination decompounded.

INTO the glaſs head of a cucurbite put thin plates of Lead, and ſecure them ſo that they may not fall out when the head is put upon the cucurbite. Fit on this head to a wide-mouthed cucurbite containing ſome Vinegar. Set it in a ſand-bath; lute on a receiver, and diſtill with a gentle heat for ten or twelve hours. Then take off the head: in it you will find the leaden plates covered, and, in a manner, cruſted over with a white matter. This being bruſhed off with a hare's foot is what we call *Ceruſe*. The leaden plates thus cleanſed may be employed again for the ſame purpoſe, till they be wholly converted into Ceruſe by repeated diſtillations. During the operation there will come over into the receiver a liquor ſomewhat turbid and whitiſh. This is a diſtilled Vinegar in which ſome Lead is diſſolved.

Reduce a quantity of Ceruſe into powder; put it into a matraſs; pour on it twelve or fifteen times as much diſtilled Vinegar; ſet the matraſs in a ſand-bath; leave the matter in digeſtion for a day, ſhaking it from time to time: then decant your liquor, and keep it apart. Pour freſh Vinegar on what is left in the matraſs, and digeſt as before. Proceed thus till you have diſſolved one half, or two thirds, of the Ceruſe.

Evaporate to a pellicle the liquors you poured off from the Ceruſe, and ſet them in a cool place. Greyiſh cryſtals will ſhoot therein. Decant the liquor from the cryſtals; evaporate it again to a pellicle, and ſet it by to cryſtallize. Proceed thus evaporating and cryſtallizing, as long as any cryſtals will ſhoot. Diſſolve your cryſtals in diſtilled Vinegar, and evaporate the ſolution, which will then ſhoot into whiter and purer cryſtals. This is the *Salt* or *Sugar of Lead.*

OBSERVATIONS.

LEAD is eaſily diſſolved by the Acid of Vinegar. If it be barely expoſed to the vapour of that Acid, its ſurface is corroded, and converted into a kind of calx or white ruſt, much uſed in painting and known by the name of *Ceruſe* or *White Lead.* But this preparation of Lead is not combined with a ſufficient quantity of Acid to convert it into a Salt: it is no more than Lead divided and opened by the Acid of Vinegar; a matter which is to Lead what Verdegris is to Copper. And therefore if you deſire to combine Ceruſe with the quantity of Acid neceſſary to convert it into a true Neutral Salt, you muſt treat it in the ſame manner as we did Verdegris in order to procure Cryſtals of Copper; that is, you muſt diſſolve it in diſtilled Vinegar, as the proceſs directs.

The Salt of Lead is not very white when it firſt ſhoots; and for this reaſon it is diſſolved again in diſtilled Vinegar, and cryſtallized a ſecond time. If Salt of Lead be repeatedly diſſolved in diſtilled Vinegar, and the liquor evaporated, it will grow thick; but ſtill cannot be deſiccated without great difficulty. If the ſame operation be oftener repeated, this quality will be thereby more and more increaſed; till at laſt it will remain on the fire like an Oil or melted Wax: it coagulates as it cools, and then looks, at firſt ſight, like a metallic maſs, ſomewhat reſembling Silver. This matter runs with a very gentle heat, almoſt as eaſily as wax.

The Salt of Lead hath a ſaccharine taſte, which hath procured it the name alſo of Sugar of Lead. For this reaſon when Wine begins to turn ſour, the ſure way to cure it of that diſagreeable taſte is, to ſubſtitute a ſweet one which is not diſagreeable to the taſte, by mixing therewith Ceruſe, Litharge, or ſome ſuch preparation of Lead: for the Acid of the Wine diſſolves the Lead, and therewith forms a Sugar of Lead, which remains mixed with the Wine, and hath a taſte which, joined with that of the Wine, is not unpleaſant. But, as Lead is one of the moſt dangerous poiſons we know, this method ought never to be practiſed; and who-ever uſes ſuch a pernicious drug deſerves to be moſt ſeverely puniſhed. Yet ſome thing very like this happens every day, and muſt needs have very bad conſequences; while there is no body to blame, and thoſe to whom the thing may prove fatal can have no miſtruſt of it.

All the retailers of Wine have a cuſtom of filling their bottles on a counter covered with Lead, having a hole in the middle, into which a Leaden pipe is ſoldered. The Wine which they ſpill on the counter, in filling the bottles, runs through this pipe into a Leaden veſſel below. In that it uſually ſtands the whole day, or perhaps ſeveral days; after which it is taken out of the Leaden veſſel, and mixed with other Wine, or put into the bottle of ſome petty cuſtomer. But, alas for the man to whoſe lot ſuch Wine falls! He muſt feel the moſt fatal effects from it; and the danger to which he is expoſed is ſo much the greater, the longer the Wine hath ſtood in the Leaden veſſel, and thereby acquired a more noxious quality. We daily ſee cruel diſtempers, among the common people, occaſioned by ſuch cauſes, which are not ſufficiently attended to.

Wine that is not kept in cloſe veſſels is apt to turn ſour very ſoon, eſpecially in the ſummer; and the retailers of Wine have obſerved that their drippings, thus collected in veſſels of Lead, are not liable to this inconvenience. This is what hath eſtabliſhed among them the practice I am ſpeaking againſt. As they ſee only the good effects thereof, and know nothing of its ill conſequences, we cannot be angry with them. It is natural to think, that, as Lead hath the property of keeping Wine cool, it may by that means prevent its growing ſour for ſome time; and perſons who are not verſed in Chymiſtry can hardly ſuſpect that Wine is preſerved from being pricked, only by being converted into a kind of poiſon. Yet this is the very caſe: for Lead doth not hinder the Wine from growing ſour; but, uniting with its Acid, as ſoon as it appears, and forming therewith a Sugar of Lead, changes the taſte thereof as hath been ſaid, and hinders the Acid from affecting the palate.

Hence it appears how much it were to be wiſhed that the uſe of thoſe counters covered with Lead were aboliſhed entirely. I am informed, by a Chymiſt zealous for the public good[*], that he repreſented this matter to the Magiſtrates ſeveral years ago. It is not to be doubted, that, when the dealers in Wine know the ill conſequences attending this practice, they will with pleaſure ſacrifice the ſmall benefit they receive from it to the publick ſafety.

It is eaſy to prove whether or no a ſuſpected Wine contains Lead. You need only pour into it a little Oil of Tartar *per deliquium*; or, if you have not that at hand, a lye of the aſhes of green wood. If there be any Lead diſſolved in it, the liquor will immediately grow turbid, and the Lead will precipitate in the form of a white powder; becauſe the Sugar of Lead it contains, being a Neutral Salt whoſe baſis is a metal, is decompounded by the Fixed Alkali, which ſeparates that metal from the Acid. Lead thus ſeparated from the Acid of Vinegar by an Alkali is called *Magiſtery of Lead.*

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[*] Mr. Rouelle, whom I have had occaſion to mention ſeveral times in this work with the honour which he deſerves, and with whom I went through a Courſe of Chymiſtry when I was a Student in Medicine. It muſt be obſerved, to the praiſe of this ingenious Artiſt, that he is the firſt Frenchman that ever gave Courſes of Chymiſtry. In theſe he explains the operations according to the true and ſound Theory of the Science drawn from the writings of Beccher, Stahl, Juncker, Boyle, Boerhaave, Hoffman, and many other excellent Chymiſts, whom it would be tedious to mention here, as well as from the Memoirs of the moſt celebrated Academies, particularly thoſe of the Academy of Sciences at Paris.

Ceruſe, or White Lead, is alſo a very dangerous poiſon. It is a pigment very much uſed, being the only White that can be applied with Oil. This White is the moſt common, or perhaps the only cauſe of thoſe dreadful colicks, with which painters, and all that work in colours, are frequently afflicted. This induced me to examine all the ſubſtances capable of affording a White, in order to find one, if poſſible, which might be ſubſtituted for White Lead: but, after a vaſt number of experiments, I had the mortification to be convinced that all Whites, even the brighteſt and moſt beautiful, which are not metallic, produce nothing, when ground with Oil, but greys, or dirty yellows. There is ſtill ſomething to be hoped for in Whites obtainable from certain metallic ſubſtances: but, as every one of thoſe matters may be ſuſpected of ſome noxious quality, long experience alone will remove our juſt apprehenſions of danger from every thing afforded by ſuch ſubſtances.

To return to the Salt of Lead: it may be decompounded by diſtillation without additament. In order to perform this, you muſt put the Salt of Lead into a glaſs or ſtone retort, leaving a full third thereof empty, and diſtill in a reverberating furnace with degrees of fire. A ſpirit riſes, which fills the receiver with clouds. When nothing more will come over with a fire that makes the retort red-hot, let the veſſels cool, and then unlute them. You will find in the receiver an auſtere liquor, which is inflammable; or, at leaſt, an inflammable Spirit may be obtained from it, if about one half thereof be drawn off by diſtillation in a glaſs alembic. The retort in which the Salt of Lead was decompounded contains, at the end of the operation, a blackiſh matter: this is Lead, which will reſume its metallic form on being melted in a crucible; becauſe the Acid by which it was diſſolved, and from which it hath been ſeparated, being of a very oily nature, hath left in it a ſufficient quantity of phlogiſton.

What is moſt remarkable in this decompoſition of Salt of Lead is the inflammable Spirit which it yields, though the Vinegar which entered into the compoſition of the Salt ſeemed to contain none at all.

CHAP. VII.

OF THE PUTRID FERMENTATION OF VEGETABLE SUBSTANCES.

PROCESS I.

The Putrefaction of Vegetables.

FILL a hogſhead with green plants, and tread them down a little; or, if the vegetables be dry and hard ſubſtances, divide them into minute parts, and ſteep them a little in water to moiſten them: then leave them, or the green plants, in the veſſel, uncovered and expoſed to the open air. By degrees a heat will ariſe in the center of the veſſel, which will continue increaſing daily, at laſt grow very ſtrong, and be communicated to the whole maſs. As long as the heat is moderate, the plants will retain their natural ſmell and taſte. As the heat increaſes, both theſe will gradually alter, and at laſt become very diſagreeable, much like thoſe of putrid animal ſubſtances. The plants will then be tender as if they had been boiled; or even be reduced to a kind of pap, more or leſs liquid according to the quantity of moiſture they contained before.

OBSERVATIONS.

ALMOST all vegetable matters are ſuſceptible of putrefaction; but ſome of them rot ſooner, and others more ſlowly. As putrefaction is only a ſpecies of fermentation, the effect whereof is to change entirely the ſtate of the Acid, by combining it with a portion of the earth and Oil of the mixt, which are ſo attenuated that from this union there reſults a new ſaline ſubſtance in which no Acid is diſcernible; which on the contrary hath the properties of an Alkali, but rendered Volatile; it is plain, that, the nearer the Acid of a plant ſet to putrefy is to this ſtate, the ſooner will the putrefaction of that plant be completed. Accordingly all plants that contain a Volatile Alkali ready formed, or from which it can be obtained by diſtillation, are the moſt diſpoſed to putrefaction.

Thoſe plants, in which the Acid is very manifeſt and ſenſible, are leſs apt to putrefy; becauſe all their Acid muſt undergo the change above ſpecified. But vegetable matters, whoſe Acid is entangled and clogged by ſeveral of their other principles, muſt be ſtill longer elaborated before they can be reduced to the condition into which complete putrefaction brings all vegetables. The earthy and oily parts, in which the Acids of theſe ſubſtances are ſheathed, muſt be attenuated and divided by a previous fermentation, which, of thoſe parts ſubtilized and united with the Acid, forms an Ardent Spirit, wherein the Acid is more perceptible than in the almoſt inſipid or ſaccharine juices out of which it is produced. The Acid contained in the Ardent Spirit muſt be ſtill further diſengaged, before it can enter into the combination of a Volatile Alkali:

conſequently the Ardent Spirit muſt undergo a ſort of decompoſition; its Acid muſt be rendered more ſenſible, and be brought to the ſame condition as the Acid of plants in which it manifeſts all its properties.

Hence it appears that the ſpirituous and acetous fermentations are only preparatives which nature makes uſe of for bringing certain vegetable matters to putrefaction. Theſe fermentations therefore muſt be conſidered as advances towards that putrefaction in which they terminate, or rather as the firſt ſtages of putrefaction itſelf. This is the opinion of Mr. Stahl, who hath treated this ſubject with great ſagacity, and thrown much light upon it.

Mr. Boerhaave is not altogether of the ſame mind. He conſiders putrefaction as ſomething foreign to fermentation; as an operation independent of it, and very different from it. He gives the title of fermentation to that inteſtine and ſpontaneous motion only which produces an Ardent Spirit, and changes it into an Acid. He founds his opinion on this, that the circumſtances attending putrefaction are different from thoſe which accompany ſpirituous and acetous fermentation; that the product of putrefaction is very different from the products of theſe fermentations; and laſtly, that all vegetable and animal ſubſtances are ſuſceptible of putrefaction, whereas only ſome kinds of them are capable of fermentation properly ſo called.

Mr. Boerhaave is ſo far right, that we ought not to confound together operations which differ in ſeveral reſpects, and reſult in different productions; but Mr. Stahl's opinion muſt nevertheleſs be looked on as highly probable, or rather abſolutely true. For it doth not neceſſarily follow, from the difference between the circumſtances and productions of fermentative motions, that the operations have no relation to, or connection with, each other. They may nevertheleſs be conſidered as different ſteps of one and the ſame operation: and if all vegetable and animal matters are not ſuſceptible of the three degrees of fermentation, we can only infer from thence that there are mixts, in which the whole work of fermentation is yet to do; and that there are others whoſe principles are ſo diſpoſed that they are in the ſame condition as if they had already undergone the firſt, or even the ſecond, degree of fermentation; and conſequently ſuch mixts are ſuſceptible only of the ſecond, or perhaps of the third, degree of fermentation.

Mr. Stahl therefore ſays very judiciouſly, that, far from denying putrefaction to be a fermentation, we ought on the contrary to conſider all fermentation as no other than putrefaction. Matters ſuſceptible of the ſpirituous and acetous fermentation do but paſs through theſe previous alterations in their way to complete putrefaction. On this principle Wine and Vinegar are only liquors that had begun to putrefy, but were ſtopt at the firſt or ſecond ſtage of their putrefaction. This is ſo true, that, if a fermenting liquor be left to itſelf in the open air, and in a due degree of heat, it will proceed directly, without any ſtop, to perfect putrefaction.

The acetous fermentation is attended with more heat than the ſpirituous, and the putrid with ſtill more than the acetous. The heat of putrefying plants is ſometimes ſo conſiderable, that, when they are not too moiſt, and are ſtacked up in great heaps, they take fire and burn violently. Of this there are frequent inſtances in hay-ricks.

PROCESS II.

Putrefied Vegetable ſubſtances analyzed.

PUT the putrefied plants you mean to analyze into a glaſs cucurbite, and ſet it in a ſand-bath. Fit to it a head; lute on a receiver; diſtill with a gentle fire, and a limpid fetid liquor will come over. Continue the diſtillation till the matter contained in the retort be almoſt dry.

Then unlute your veſſels, and keep the liquor you find in the receiver by itſelf. Put the matter remaining in the cucurbite into a retort, and diſtill with a graduated heat. There will riſe white vapours; a pretty conſiderable quantity of liquor nearly like that of the former diſtillation; a Volatile Salt in a concrete form; and a black oil, which towards the end will be very thick. In the retort there will remain a black charred matter, which being burnt in the open air will fall into aſhes, from which no Fixed Alkali can be extracted.

By means of a funnel ſeparate your oil from the aqueous liquor. Diſtill this liquor with a gentle heat. You will by this means obtain a Volatile Salt like that of animals; of which you may alſo get ſome, by the ſame means, from the liquor which came over in the firſt diſtillation.

OBSERVATIONS.

THIS analyſis ſhews the changes which putrefaction produces in vegetable matters. Scarce any of their principles are now to be diſcerned. They now yield no aromatic liquor; no Eſſential Oil; no Acid; and conſequently no Eſſential Salt, Ardent Spirit, or Fixed Alkali: in a word, whatever their natures were before putrefaction, they are all alike when they have once undergone this fermentative motion in its full extent. Nothing can then be obtained from them but Phlegm, a Volatile Alkali, a fetid Oil, and an inſipid Earth.

Almoſt all theſe changes are owing to the tranſmutation of the Acid, which is depraved by putrefaction, and combined with a portion of the Oil and ſubtilized Earth of the mixt; ſo that the reſult of their union is a Volatile Alkali. Now, as the Fixed Alkali, found in the aſhes of unputrefied plants, is only the moſt fixed part of their earth and of their Acid, cloſely united together by the igneous motion, it is not ſurpriſing that, when all the Acid, with a part of the earth, is ſubtilized and volatilized by putrefaction, no Fixed Alkali can be found in the aſhes of putrefied Vegetables. The alteration which the Acid ſuffers by the putrefactive motion is, in my opinion, the greateſt it can undergo, without being entirely deſtroyed and decompoſed, ſo as to be no longer a Salt.

We have ſeen it, in the Mineral kingdom, in its greateſt purity and ſtrength. Its combination with Oil, and the other alterations it undergoes, in the Vegetable kingdom, have ſhewn it weakened and diſguiſed. The changes it ſuffers by the ſpirituous and acetous fermentation, have exhibited it in other forms. And, laſtly, putrefaction disfigures it completely, and, in ſome ſort, changes its very nature, ſo that it cannot be diſtinguiſhed. In the animal kingdom we find it nearly in the ſame condition: for though the Vegetable ſubſtances, on which animals feed, do not undergo direct putrefaction, in its full extent, before they are converted into animal juices, yet they ſuffer moſt of the alterations produced by putrefaction; ſo that when they have acquired the qualities neceſſary to their becoming an actual nutritious animal juice, they are within one ſtep of complete putrefaction. For this reaſon all animal ſubſtances are very apt to putrefy, and are unſuſceptible of the firſt degrees of fermentation. But this diſcuſſion belongs to the animal kingdom, of which we are now going to treat in the third part of theſe Elements; the theory of putrefaction ſerving to introduce it, and naturally leading us to it.

PART III.

Of Operations on Animal ſubſtances.

CHAP. I.

OF MILK.

PROCESS I.

Milk ſeparated into Butter, Curd, and Whey: inſtanced in Cow's-Milk.

PUT new Cow's milk into a flat earthen pan, and ſet it in a temperate heat. In ten or twelve hours time there will gather on its ſurface a thick matter, of a ſomewhat yellowiſh white: this is called *Cream.* Gently ſkim off this Cream with a ſpoon, letting the milk you take up with it run off. Put all this Cream into another veſſel, and keep it. The milk thus ſkimmed will not be quite ſo thick as before: nor will it be of ſuch a dead white, but have a little blueiſh caſt. If all the Cream be not ſeparated from it, more will gather on its ſurface after ſome time, which muſt be taken off as the former. In two or three days the ſkimmed milk will coagulate into a ſoft maſs called *Curd*, and then it taſtes and ſmells ſour.

Cut this Curd acroſs in ſeveral places. It will immediately diſcharge a large quantity of *Serum*. Put the whole into a clean linnen cloth; hang it up, and underneath it ſet a veſſel to receive the Serum as it drops. When the aqueous part hath done dripping, there will remain in the filter a white ſubſtance ſomewhat harder than the curdled milk. This ſubſtance is called *Cheeſe*, and the *Serum* ſeparated from it is known by the name of *Whey*.

OBSERVATIONS.

The milk of animals, that feed only on vegetables, is of all animal matters the leaſt removed from the vegetable nature. The truth of this will be demonſtrated by the experiments we ſhall produce by and by, for the further analyſis of milk. For this reaſon we judged, with Mr. Boerhaave, that it was proper to begin the analyſis of animals by examining this liquor.

Moſt Chymiſts juſtly conſider Milk as of the ſame nature with Chyle. Indeed there is great reaſon to think, that, except ſome ſmall differences to be afterwards taken notice of, theſe two matters are nearly the ſame. They are both of a dead white colour, like that of an emulſion; which proves that, like emulſions, they conſiſt of an oily matter divided, diffuſed, and ſuſpended, but not perfectly diſſolved, in an aqueous liquor.

It is not ſurpriſing that theſe liquors ſhould reſemble emulſions; for they are produced in the ſame manner, and may very juſtly be called *Animal Emulſions*. For how are vegetable ſubſtances converted into Chyle and Milk in an animal body? They are bruiſed, divided, and triturated by maſtication and digeſtion, as perfectly, at leaſt, as the matters pounded in a mortar to make an emulſion; and muſt thereby undergo the ſame changes as thoſe matters; that is, their oily parts, being attenuated by thoſe motions, muſt be mixed with and lodged between the aqueous parts, but not diſſolved therein; becauſe they do not, in the bodies of animals, meet with ſaline matters, ſufficiently diſentangled and active, to unite intimately with them, and by that means render them ſoluble in water.

Nevertheleſs Chyle and Milk, though produced in the ſame manner as emulſions, and very much reſembling them, differ greatly from them in ſome reſpects; owing chiefly to the time they remain in the bodies of animals, their being heated while there, the elaborations they undergo therein, and the animal juices commixed with them.

New Milk hath a mild agreeable taſte, without any ſaline pungency; nor hath any Chymical trial diſcovered in it either an Acid or an Alkali. Yet it is certain that the juices of plants, out of which milk is formed, contain many ſaline matters, and eſpecially Acids: accordingly Milk alſo contains the ſame; but the Acids are ſo ſheathed and combined, that they are not perceptible. The caſe is the ſame with all the other liquors intended to conſtitute part of an animal body: there is no perceptible Acid in any of them.

Hence it may be inferred that one of the principal changes which vegetables undergo, in order to their being converted into an animal ſubſtance, conſiſts in this, that their Acids are combined, entangled, and ſheathed in ſuch a manner that they become imperceptible, and exert none of their properties.

Milk left to itſelf, without the help of diſtillation, or any additament whatever, undergoes a ſort of decompoſiton. It runs into a kind of ſpontaneous analyſis; which doth not indeed reduce it to its firſt principles, yet ſeparates it into three diſtinct ſubſtances, as the proceſs ſhews; namely, into Cream, or the buttery fat part, into Curd or Cheeſe, and into Serum or Whey: which ſhews that thoſe three ſubſtances of which Milk conſiſts, are only mixed and blended together, but not intimately united.

The firſt parts, being the lighteſt, riſe gradually to the ſurface of the liquor as they ſeparate from the reſt: and this forms the Cream.

Cream, as ſkimmed from the ſurface of Milk, is not however the pure buttery or fat part; it is ſtill mixed with many particles of Cheeſe and Whey, which muſt be ſeparated in order to reduce it into Butter. The moſt ſimple, and at the ſame time the beſt method of effecting this, is daily practiſed by the country people. It conſiſts in beating or churning the Cream, in a veſſel contrived for that purpoſe, with the flat ſide of a circular piece of wood, in the center of which a ſtaff is fixed. One would think that the motion, impreſſed on the Cream by this inſtrument, ſhould rather ſerve to blend more intimately the particles of Butter, Cheeſe, and Whey, of which it conſiſts, than to ſeparate them from each other; as this motion ſeems perfectly adapted to divide and attenuate thoſe particles. But, if we conſider what paſſes on this occaſion, we ſhall ſoon perceive that the motion by which Butter is churned is nothing like triture: for churning is no other, properly ſpeaking, than a continually repeated compreſſion, the effect whereof is to ſqueeze out from amongſt the buttery particles thoſe of Cheeſe and Whey mixed therewith; by which means the particles of Butter are brought into contact with each other, unite, and adhere together.

Milk, whether ſkimmed or no, grows ſour of itſelf, and curdles in a few days. When it is newly curdled, the Cheeſe and Whey ſeem to be united, and to make but one maſs: but theſe two matters ſeparate ſpontaneouſly from each other, with the greateſt eaſe, and in a very ſhort time.

The acidity, which Milk naturally contracts in the ſpace of a few days, muſt be conſidered as the effect of a fermenting motion, which diſcovers in that liquor an Acid that was not perceptible before. This, properly ſpeaking, is an acetous fermentation, which Milk paſſes through in its way to putrefaction; and it ſoon follows, eſpecially if the Milk be expoſed to a hot air.

If, inſtead of leaving Milk to grow ſour and curdle of itſelf, an Acid be mixed therewith, while it is yet ſweet and newly milked, it immediately coagulates; which gives reaſon to think that its curdling naturally is the effect of the Acid, which diſcovers itſelf therein as it grows ſtale.

The coagulation of Milk may alſo be conſiderably accelerated, by ſetting it in a ſand-bath gently heated; or by mixing therewith a little of what, in the language of the Dairy, is called *Runnet*; which is nothing but ſome curdled and half-digeſted Milk taken from the ſtomach of a Calf: or both theſe methods may be employed at once, which will produce the effect ſtill more expeditiouſly.

It is not difficult to find out the cauſe of theſe effects. The Runnet, which is Milk already curdled and grown ſour, is an actual ferment to ſweet Milk, diſpoſing it to turn ſour much more readily: for though Milk, when thus haſtily curdled by the Runnet, hath not a manifeſtly acid taſte, yet it is certain that this Acid begins to exert itſelf. The proof thereof is, that, being expoſed to the ſame degree of heat with Milk equally new, that is not mixed with this ferment, it turns ſour much ſooner. As to the effect of heat in coagulating Milk, there is nothing extraordinary in it: we know how much it promotes and accelerates all fermentative motion.

The whole of this perfectly agrees with what we ſaid before concerning fermentation.

Fixed Alkalis alſo coagulate Milk; but at the ſame time they ſeparate the Whey from the Cheeſe, which floats on the liquor in clots. They give the Milk a ruſſet colour inclining to red; which may ariſe from their attacking the fat part.

The ſeparation of Milk into Butter, Cheeſe, and Whey, is a kind of imperfect analyſis thereof, or rather the beginning of one. In order to render it complete, we muſt examine each of theſe ſubſtances ſeparately, and find the principles of which they conſiſt. This we ſhall endeavour to do in the following proceſs.

PROCESS II.

Butter analyzed by Diſtillation.

INTO a glaſs retort put the quantity of freſh Butter you intend to diſtill. Set the retort in a reverberatory; apply a receiver; and let your fire be very gentle at firſt. The Butter will melt, and there will come over ſome drops of clear water, which will have the peculiar ſmell of freſh Butter, and ſhew ſome tokens of Acidity. If the fire be increaſed a little, the Butter will ſeem to boil: a froth will gather on its ſurface, and the phlegm, ſtill continuing to run, will gradually come to ſmell juſt like Butter clarefyed in order to be preſerved. Its Acidity will be ſtronger and more manifeſt than that of the firſt drops that came over.

Soon after this, by encreaſing the fire a little more, there will riſe an Oil, having nearly the ſame degree of fluidity as fat Oils; but it will grow thicker as the diſtillation advances, and at laſt will fix in the receiver when it cools. It will be accompanied with ſome drops of liquor, the Acidity whereof will always increaſe, while its quantity decreaſes, as the diſtillation advances.

While this thick Oil is diſtilling, the Butter contained in the retort, which at firſt ſeemed to boil, will be calm and ſmooth, without the leaſt appearance of ebullition; though the heat be then much greater than when it boiled. Continue the diſtillation, conſtantly increaſing the fire by degrees as you find it neceſſary for the elevation of the thick Oil. This Oil, or rather this kind of Butter, will be at laſt of a ruſſet colour. There will riſe along with it ſome white vapours exceeding ſharp and pungent.

When you obſerve that nothing more comes over, though the retort be quite red-hot, let the veſſels cool, and unlute them. You will find in the receiver an aqueous acid liquor, a fluid Oil, and a kind of fixed brown Butter. Break the retort and you will find therein a charred matter; the ſurface of which, where it touched the glaſs, will be of a ſhining black, and have a fine poliſh.

OBSERVATIONS.

THE analyſis of Butter proves that this ſubſtance, which is an oily matter in a concrete form, owes its conſiſtence to the Acid only, with which the oily part is combined: that is, it follows the general rule frequently mentioned above in treating of other oily compounds; the conſiſtence whereof we ſhewed to be ſo much the firmer, the more Acid they contain. The firſt portions of Oil that come over in the diſtillation of Butter are fluid, becauſe a pretty conſiderable quantity of Acid roſe before them, which being mixed with the phlegm gives it the Acidity we took notice of.

This Oil, being freed from its Acid and by that means rendered fluid, riſes firſt; becauſe it is by the ſame means rendered lighter. The kind of Butter that comes over afterwards, though it be fixed, is nevertheleſs far from having the ſame conſiſtence as it had before diſtillation; becauſe it loſes much of its Acid in the operation. This Acid is what riſes in the form of white vapours. Theſe vapours are, at leaſt, as pungent and irritating as the Sulphureous Acid or Volatile Alkalis: but their ſmell is different: it hath a reſemblance, or rather is the ſame, with that which riſes from Butter when it is burnt and browned in an open veſſel. But, when concentrated and collected in cloſe veſſels, as in the diſtillation of Butter, they are vaſtly ſtronger: they irritate the throat ſo as to inflame it; they are exceeding ſharp and pungent to the ſmell, and are ſo hurtful to the eyes that they quickly inflame them, as in an ophthalmy, and make them ſhed abundance of tears. The great volatility of this Acid is entirely owing to a portion of the phlogiſton of the Butter with which it is ſtill combined.

It may be aſked why Butter, or the oily part of Milk which hath the conſiſtence of a fixed Oil, is more replete with an Acid than the Oils of the vegetables whereof the Milk was formed; as theſe Oils are almoſt all fluid, which indicates their containing leſs Acid before than after they were digeſted in the body of an animal. This muſt appear the more extraordinary, becauſe the Acid contained in the liquors of animals is ſheathed and imperceptible, and conſequently incapable of combining with the Oils of vegetables ſo as to give them this conſiſtence.

I think it will be eaſy to give a ſatisfactory anſwer to this queſtion, if it be conſidered that the Oils, which exiſt in the vegetable juices whereof the Milk is formed, are far from being combined with the whole Acid of thoſe vegetables; becauſe there is hardly a plant that doth not yield a great deal of Acid, even without the help of fire. Now, there is reaſon to think that one of the principal effects of digeſtion is to combine and unite this Acid with the oily parts of vegetables more intimately than it was before.

The further we advance in the analyſis of animals, the more we ſhall be convinced, that, in the different elaborations, which vegetable ſubſtances undergo in order to their being changed into the nutritious juices of animals, nature employs all her powers to expell, deſtroy, or at leaſt, weaken and blunt the Acids, ſo as to render them abſolutely imperceptible. One of the beſt means by which ſhe can effect this, is the combining and uniting them intimately with the oily parts: and this operation ſhe probably begins in digeſtion. She gets rid of moſt part of the Acids contained in the aliments, by thus uniting them with the Oils contained in thoſe aliments. Hence ariſes the conſiſtence of Butter, which is the fat part of Milk, that is, of a liquor half-changed into an animal juice.

This explication furniſhes us alſo with the reaſon why Acids agree ſo ill with people of weak and delicate conſtitutions. The motion and heat in their bodies is not ſufficient to effect a due combination of the Acids with the Oils. Hence it comes to paſs, that, during and after digeſtion, they find in their bowels the bad effects of thoſe Acids, in the diſorder commonly called the *Heart-burn.* Hence alſo it is that ſuch people receive great benefit from the uſe of Abſorbents, which uniting with the Acids neutralize them, and relieve nature when ſhe has not ſtrength enough herſelf to get the better of them.

To return to our analyſis of Butter: we took notice in the proceſs that Butter ſeems to boil with a very moderate heat, at the beginning of the diſtillation, and that in the courſe of the operation the ebullition ceaſes entirely, though the heat be then greatly increaſed; which is contrary to the general rule. The reaſon is that Butter, though a ſeemingly homogeneous maſs, contains nevertheleſs ſome particles of Cheeſe and Whey. The particles of Whey, being much the lighteſt, endeavour, on the firſt application of heat, to extricate themſelves from amongſt the particles of Butter, and to riſe in diſtillation. Thus they form the drops of acidulated phlegm which come over at firſt, and, in ſtruggling to get free, lift up the buttery parts, or actually boil, which occaſions the ebullition obſervable at the beginning of the proceſs. When they are once ſeparated, the melted Butter remains calm and ſmooth, without boiling. If you want to make it boil you muſt apply a much greater degree of heat; which you cannot do in cloſe veſſels, without ſpoiling the whole operation: becauſe the degree of heat neceſſary for that purpoſe would force up the Butter in ſubſtance, which would ruſh over into the receiver, without any decompoſition. Indeed if the veſſels were luted they would be in danger of burſting.

As to the caſeous parts, which are mixed with freſh Butter, they alſo ſeparate at the beginning of the diſtillation when the Butter is melted, and gather on its ſurface in a ſcum. Theſe particles of Cheeſe and Whey, which are heterogeneous to Butter, help to make it ſpoil the ſooner. And for this reaſon thoſe who want to keep Butter a long time, without the uſe of ſalt, melt it, and thereby evaporate the aqueous parts. The lighteſt portion of the particles of Cheeſe riſes to the ſurface, and is ſkimmed off; the reſt remains at the bottom of the veſſel, from which the Butter is eaſily ſeparated, by decanting it while it is yet fluid.

Butter may alſo be diſtilled, by incorporating it with ſome additament which will yield no principle itſelf, nor retain any of thoſe of the Butter. I have diſtilled it in this manner with the additament of fine ſand: the operation ſucceeds very well, is ſooner finiſhed, and more eaſily conducted: but I choſe to deſcribe here the manner of doing it without additament; becauſe the ſeveral changes, which the Butter undergoes in the retort during the operation, may be better obſerved.

If you deſire to convert the Butter wholly into Oil, you muſt take the fixed matter you find in the receiver, and diſtill it once more, or oftener, according to the degree of fluidity you want to give it. The caſe is the ſame with this matter as with all other thick Oils, which, the oftener they are diſtilled, grow always the more fluid, becauſe in every diſtillation they are ſeparated from part of the Acid, to which alone they owe their conſiſtence.

PROCESS III.

The Curd of Milk analyzed by diſtillation.

INTO a glaſs retort put ſome new Curd, having firſt drained it thoroughly of all its Whey, and even ſqueezed it in a linnen cloth to expreſs all its moiſture. Diſtill it as you did Butter. There will come over at firſt an acidulated phlegm, ſmelling like Cheeſe or Whey. As the diſtillation advances, the Acidity of this phlegm will increaſe.

When it begins to run but very ſlowly raiſe your fire. There will come over a yellow Oil, ſomewhat empyreumatic. Continue the diſtillation, ſtill increaſing the fire by degrees as occaſion requires. The Oil and acid Phlegm will continue to riſe; the Phlegm growing gradually more acid, and the Oil deeper coloured and more empyreumatic. At laſt, when the retort is almoſt red-hot, there comes off a ſecond black Oil, of the conſiſtence of Turpentine, very empyreumatic, and ſo heavy as to ſink in water. In the retort will be left a conſiderable quantity of charred matter.

OBSERVATIONS.

CHEESE-CURD barely drained, till no more Whey will drip from it, is not entirely freed thereof; and for this reaſon we directed it to be preſſed in a linnen cloth, before it be put into the retort to be diſtilled. Without this precaution, the remaining Whey would riſe in a conſiderable quantity on the firſt application of heat; and, inſtead of analyzing the Curd only, we ſhould at the ſame time analyze the Whey alſo. This is to be underſtood of green Curd and new-made Cheeſe; for, if it be ſuffered to grow old, it will at length dry of itſelf: but then we ſhould not obtain from it the ſame principles by diſtillation; as it corrupts and begins to grow putrid after ſome time, eſpecially if it be not mixed with ſome ſeaſoning to preſerve it.

The firſt Phlegm that riſes in this diſtillation, as in that of Butter, is a portion of the Whey that was left in the Cheeſe, notwithſtanding its being well preſſed. This Phlegm grows gradually more acid, being the vehicle of the Acids of the Cheeſe, which are forced up along with it by the fire.

The Acid obtained from this matter is leſs in quantity, and weaker, than that of Butter: and accordingly the Oil diſtilled from Cheeſe is not fixed like that of Butter. Yet it is remarkable that the laſt empyreumatic Oil, which is as thick as Turpentine, is heavier than water: a property which it probably derives from the quantity of Acid it retains.

The quantity of charred matter, which remains in the retort after the diſtillation of Cheeſe, is much greater than that left by Butter; which proves that the former contains a much greater quantity of earth. Theſe coals are exceeding difficult to burn and reduce to aſhes. I have kept them red-hot, in the open air, and in a very ſtrong fire, above ſix hours, continually ſtirring them, in order to bring the under parts to the ſurface, that they might be burnt, yet I could not conſume them entirely. They even deflagrated afterwards with Nitre, as if they had not been burnt at all; and yet, during the whole time of their calcination, there appeared conſtantly a ſmall flame, like that of charcoal, on the ſurface of the matter.

PROCESS IV.

Whey analyzed.

EVAPORATE two or three quarts of Whey almoſt to dryneſs in a *balneum mariæ*; and diſtill the extract or reſiduum in a retort ſet in a reverberating furnace, with degrees of fire, according to the general rule. At firſt ſome Phlegm will come over; then a lemon-coloured acid Spirit; and afterwards a pretty thick Oil. There will remain in the retort a charred matter, which being expoſed to the air grows moiſt. Lixiviate it with rain water, and evaporate the lixivium: it will yield you cryſtals of Sea-ſalt. Dry the charred matter, and burn it in the open air with a ſtrong fire, till it be reduced into aſhes. A lixivium of theſe aſhes will ſhew ſome tokens of a Fixed Alkali.

OBSER-

OBSERVATIONS.

MILK, as was ſaid before, ſeparates naturally and ſpontaneouſly into three ſorts of ſubſtances, the analyſes whereof being put together make a complete analyſis of this animal liquor. I know no Author that hath delivered the analyſes of Butter and Cheeſe; ſo that the proceſſes here given for analyzing theſe two ſubſtances are taken from the experiments I thought proper to make, in order to obtain the neceſſary lights in this manner. As for the analyſis of Whey, it is taken from one of Mr. Geoffroy's Memoirs, containing experiments on ſeveral animal ſubſtances, which was publiſhed in 1732. It is there ſo particularly and ſo well deſcribed, that it was needleſs for me to attempt it anew.

It will appear, on examining the three analyſes of the ſubſtances whereof Milk conſiſts, that none of them yields a Volatile Alkali: which I think very worthy of notice; as it is, I believe, the only animal matter from which ſuch a Salt cannot be obtained. It is true, the Milk of animals that feed on vegetables may be conſidered as an intermediate liquor between vegetable and animal ſubſtances; as an imperfect animal juice, which ſtill retains much of the vegetable nature: and we actually find that Milk almoſt always hath, at leaſt in part, the properties of thoſe plants with which the animals that yield it are fed. Yet, as it cannot be formed in the body of the animal, without mixing with ſeveral of its juices that are entirely perfected, and become purely animal, it muſt appear ſtrange that the analyſis thereof ſhould not afford the leaſt veſtige of that principle, which all other animal matters yield in the greateſt plenty.

I imagine the reaſon of this may be found in the uſe to which Milk is deſtined. It is intended for the nouriſhment of animals of the ſame ſpecies with thoſe in whoſe bodies it is produced. Conſequently it ought as much as poſſible to reſemble the juices of the food which is proper for thoſe animals. Now, as animals that live only on vegetables could not be properly nouriſhed by animal matters, for which nature itſelf hath even given them an averſion, it is not ſurpriſing that the Milk of ſuch animals ſhould be free from any mixture of ſuch things as are unſuitable to the young ones whom it is deſigned to nouriſh. There is reaſon therefore to think that nature hath diſpoſed the organs, in which the ſecretion of Milk is performed, ſo as to ſeparate it entirely from all the animal juices firſt mixed with it: and this I take to be the principal difference between Milk and Chyle; the latter being neceſſarily blended with the ſaliva, the gaſtric and pancreatic juices, the bile and lymph, of the animals in which it is formed. Hence it may be concluded, that, if a quantity of Chyle could be collected ſufficient to enable us to analyze it, the analyſis thereof would differ from that of Milk, in this chiefly that it would yield a great deal of Volatile Alkali, of which Milk, as hath been ſaid, yields none at all.

The ſame thing probably takes place in carnivorous animals. It is certain that thoſe animals chuſe to eat the fleſh of ſuch others only as feed upon vegetables; and that nothing but extreme hunger, and the abſolute want of more agreeable food, will force them to eat the fleſh of other carnivorous animals. Wolves, which greedily devour ſheep, goats, &c. ſeldom eat Foxes, Cats, Polecats, &c. though theſe animals are not ſtrong enough to reſiſt them. Foxes, Cats, and Birds of prey, that make ſuch terrible havock among wild fowl, and other ſorts of game, do not devour one another. This being laid down, there is reaſon to think that the Milk of carnivorous animals is ſomething of the nature of the fleſh of thoſe animals that feed on vegetables, and which they chuſe to eat, and not of the nature of their own fleſh; as the Milk of animals that feed on vegetables is analogous to the juice of vegetables, and when analyzed yields no Volatile Alkali, though every other part of their body does.

But whatever be the nature of Milk, and of whatever ingredients it be formed, it always contains the three ſeveral ſubſtances above mentioned; namely, the fat, or Buttery part, properly ſo called, the Cheeſy, and the Serous part, the laſt of which we are now to examine. It is, properly ſpeaking, the Phlegm of the Milk, and conſiſts almoſt entirely of water. For this reaſon it is proper to leſſen the quantity thereof conſiderably by evaporation, ſo that its other principles, being concentrated and brought nearer together, may become much more ſenſible. There is no danger of loſing any eſſential part of the Whey in the evaporation, if it be performed in the *balneum mariæ* with ſuch a gentle heat as may carry off the aqueous parts only: this greatly ſhortens the analyſis, which will be exceeding long and tedious if all the water be diſtilled off in cloſe veſſels.

As Whey is chiefly the aqueous part of Milk, as ſaid above, it muſt contain all the principles thereof that are ſoluble in water; that is, its ſaline and ſaponaceous parts. And accordingly the analyſis thereof ſhews that it contains an Oil, rendered perfectly ſaponaceous by an Acid; that is, made perfectly miſcible with water. This quality of the Oil contained in Whey appears from the perfect tranſparency of that liquor, which we know is the mark of a complete diſſolution. In the diſtillation of Whey, the ſaponaceous matter contained therein is decompoſed; the ſaline part riſes firſt, as being the lighteſt; this is the Acid taken notice of in the proceſs; after which the Oil, now ſeparated from the principle which rendered it miſcible with water, comes over in its natural form, and doth not afterwards mix with the aqueous part.

Beſides the ſaponaceous matter, Whey contains alſo another ſaline ſubſtance; namely, Sea-Salt: this is obtained by lixiviating the *caput mortuum* left in the retort, which, becauſe of its fixedneſs, cannot riſe with the other principles in diſtillation. To this Salt it is owing that what remains in the retort after diſtillation grows moiſt in the air; for we know that Sea-ſalt thoroughly dried hath this property.

The fixed Alkaline Salt, obtained from the *caput mortuum* burnt to aſhes, proves that Milk ſtill retains ſomething of the vegetable nature: for the following analyſis will ſhew us that matters purely animal yield none at all.

CHAP. II.

OF THE SUBSTANCES WHICH COMPOSE AN ANIMAL BODY.

PROCESS I.

Blood analyzed. Inſtanced in Bullock's Blood.

IN a *balneum mariæ* evaporate all the moiſture of the Blood that the heat of boiling water will carry off. There will remain an almoſt dry matter. Put this dried Blood into a glaſs retort, and diſtill with degrees of heat, till nothing more will come over, even when the retort is quite red-hot, and ready to melt. A browniſh phlegm will riſe at firſt: this will ſoon be impregnated with a little Volatile Alkali, and then will come over a yellow Oil, a very pungent Volatile Spirit, a Volatile Salt in a concrete form, which will adhere to the ſides of the receiver; and, at laſt, a black Oil, as thick as pitch. There will be left in the retort a charred matter, which being burnt yields no Fixed Alkali.

OBSERVATIONS.

BLOOD, which is carried by the circulation into all the parts of the animal body, and furniſhes the matter of all the ſecretions, muſt be conſidered as a liquor conſiſting of almoſt all the fluids neceſſary to the animal machine: ſo that the analyſis thereof is a ſort of general, though imperfect, analyſis of an animal.

Blood drawn from the body of an animal, and ſet by in a veſſel, coagulates as it grows cold; and ſometime afterwards the *coagulum* diſcharges a yellowiſh *Serum* or lymph; and in the midſt thereof ſwims the red part, which continues curdled. Theſe two ſubſtances, when analyzed, yield nearly the ſame principles; and in that reſpect ſeem to differ but little from each other. Though the Serum of Blood be naturally in a fluid form, yet it hath alſo a great tendency to coagulate, and a certain degree of heat applied to it, either by water or by a naked fire, will curdle it. Spirit of Wine mixed with this liquor produces on it the ſame effect as heat.

Blood, while circulating in the body of a healthy animal, and when newly taken from it, hath a mild taſte, which diſcovers nothing like either an Acid or an Alkali; nor doth it ſhew any ſign of either the one or the other in Chymical trials. When taſted with attention it betrays ſomething like a ſavour of Sea-ſalt; becauſe it actually contains a little thereof, which is found in the charred matter left in the retort after diſtillation, when carefully examined.

We ſhewed that Milk alſo contains a little of this Salt. It enters the bodies of animals with the food they eat, which contains more or leſs thereof according to its nature. It plainly ſuffers no alteration by undergoing the digeſtions, and paſſing through the ſtrainers, of the animal body. The caſe is the ſame with the other Neutral Salts which have a Fixed Alkali for their baſis: we find them unchanged in the juices of animals into whoſe bodies they have been introduced. They are incapable of combining, as Acids do, with the oily parts; and ſo are diſſolved by the aqueous fluids, of which nature makes uſe to free herſelf from thoſe Salts, and diſcharge them out of the body; as ſhall be ſhewn when we come to ſpeak of Urine and Sweat.

Blood, like all other animal matters, is, properly ſpeaking, ſuſceptible of no fermentation but that of putrefaction. Yet it turns ſomewhat ſour before it putrefies. This ſmall degree of acetous fermentation is moſt ſenſible in fleſh; and eſpecially in the fleſh of young animals, ſuch as calves, lambs, chickens, &c.

The quantity of pure water, which Blood, in its natural ſtate, contains, is very conſiderable, and makes almoſt ſeven eighths thereof. If it be diſtilled, without being firſt dried, the operation will be much longer; becauſe it will be neceſſary to draw off all this inſipid phlegm with a gentle fire. There is no reaſon to apprehend that, by drying Blood in open veſſels as directed, any of its other principles will be carried off with its Phlegm: for it contains no other ſubſtance that is volatile enough to riſe with the warmth of a *balneum mariæ.* This may be proved by putting ſome undried Blood into a glaſs cucurbite, fitting thereto a head and receiver, and diſtilling, in a *balneum mariæ*, all that the heat of the bath, not exceeding the heat of boiling water, will raiſe: for, when nothing more will come over, you will find in the receiver an inſipid phlegm only, ſcarce differing from pure water, except in having a faint ſmell like that of Blood; wherein it reſembles all the phlegms that riſe firſt in diſtillation, which always retain ſomething of the ſmell of the matters from which they were drawn. That part of the Blood, which remains in the cucurbite after this firſt diſtillation, being put into a retort, and diſtilled with a ſtronger fire, yields exactly the ſame principles, and in the ſame proportion, as Blood dried in open veſſels in the *balneum mariæ*: ſo that, if this Phlegm of Blood contains any principles, the quantity thereof is ſo ſmall as to be ſcarce perceptible.

The Volatile Alkali that riſes with the Oil, when Blood is diſtilled in a retort with a degree of heat greater than that of boiling water, is either the production of the fire, or ariſes from the decompoſition of an Ammoniacal Salt of which it made a part. For we ſhall ſee, when we come to treat of this ſaline ſubſtance, that it is ſo extremely volatile as to exceed, in that reſpect, almoſt all other bodies that we know: and therefore if this Volatile Alkali preexiſted formally in the Blood, uncombined with any other matter capable, in ſome meaſure, of fixing it, it would riſe at firſt almoſt ſpontaneouſly, or at leaſt on the firſt application of the gentleſt heat. We have an inſtance of this in Blood, or any other animal matter, that is perfectly putrefied; which containing a Volatile Alkali, either formed or extricated by putrefaction, lets go this principle when diſtilled, even before the firſt phlegm: and, for this reaſon, when putrefied Blood is to be analyzed, it muſt by no means be dried, like freſh Blood, before diſtillation; for all the Volatile Alkali would by that means be diſſipated and loſt at once.

The Volatile Alkali obtained from Blood that hath not undergone putrefaction affords matter of ſome ſpeculation. Indeed the ſeparation of this Salt from Blood requires a degree of heat vaſtly greater than that which is neceſſary to make it riſe when it is perfectly formed and diſentangled: and this gives room to think that it is the reſult of a combination formed by the fire during the diſtillation. But then this ſame degree of heat neither ſeparates nor forms any Volatile Alkali in a great number of plants, or in milk, as hath been ſhewn. Yet it cannot be ſuppoſed that the Blood of animals, which feed only on thoſe plants or on milk, is any other than theſe very matters digeſted and rendered perfectly animal ſubſtances: whence it muſt be concluded, that, when vegetable ſubſtances are converted into animal ſubſtances, they undergo ſuch alterations as render them capable of yielding, when analyzed, a principle that was not diſcoverable in them before. Now we know that this ſame principle, that is, the Volatile Alkali, is the product of putrefaction, or, which is the ſame thing, of the laſt degree of fermentation: and this, I think, makes the opinion of thoſe more than probable who believe that trituration and mechanical motion are not the only cauſes that effect the converſion of food into an animal juice, but that fermentation hath a great ſhare in this change. It is true, we do not find in animal matters any manifeſt token of an Ardent Spirit, an Acid, or a Volatile Alkali; nor, conſequently, any ſubſtance that is an evident production of any of the three different degrees of fermentation: and yet, as ſubſtances perfectly animalized are exactly in the ſame ſtate with vegetables that have undergone the firſt, and even the ſecond, degree of fermentation, ſo that they are ſuſceptible of putrefaction only; (or, at leaſt, if they ſhew at firſt ſome faint tokens of acidity, they run immediately and rapidly into complete putrefaction;) it is nevertheleſs probable that vegetable matters, in order to their becoming animal ſubſtances, undergo certain changes and alterations which have ſome reſemblance with thoſe produced by fermentation.

This opinion is further confirmed by two other analogies between animal matters, and vegetables advanced to the laſt ſtage of fermentation; which is, that they yield neither an Eſſential Oil nor a Fixed Alkali: for the coal, that remains in the retort after the diſtillation of Blood, being burnt in an open fire, diſcovers no Fixed Alkali in its aſhes.

The want of a Fixed Alkali in animal matters ariſes from hence, that their Acid is nearly in the ſame ſtate with the Acid of vegetable matters which have undergone putrefaction; that is, it is ſo ſubtilized and attenuated, as to be fit to enter into the combination of a Volatile Alkali, and is no longer ſo intimately united with the fixed earth as to produce therewith a Fixed Alkali in the fire.

Though Blood and other animal matters afford no Fixed Alkali, but, on the contrary, yield much Volatile Alkali, it doth not therefore follow that all the Acid, which thoſe ſubſtances contained before they were analyzed, is employed in the production of a Volatile Alkali. We ſhall hereafter take notice of an animal matter which contains a great deal of Acid: and, not to depart from our preſent ſubject, it doth not appear to me to be a ſettled point among Chymiſts, whether or no Blood, when analyzed, yields a portion manifeſtly acid, and poſſeſſing all the properties of an Acid.

Mr. Boerhaave, with ſome other Chymiſts, makes no mention of any Acid in his analyſis of Blood.

Mr. Homberg, on the contrary, ſays * expreſly, that he conſtantly obtained an Acid from the Blood and fleſh of different ſorts of animals, of which he analyzed a great number. Mr. Boerhaave's authority is very reſpectable, and of great weight: On the other hand, Mr. Homberg's experiments are very concluſive, ſeem to be made with great care, and are all affirmative. This apparent diverſity in the ſame analyſis, delivered by theſe two great men, determined me to analyze Blood myſelf, and to examine ſcrupulouſly all the principles I could obtain from it.

I therefore diſtilled ſome Bullock's Blood in a retort with degrees of fire. Some Phlegm came over firſt, and then a Volatile Spirit. I changed my receiver; and on increaſing the fire there roſe with the Volatile Spirit a yellow Oil, a Volatile Salt in a concrete form, a ruſſet liquor which ſmelled ſtrong of Volatile Alkali, and ſeemed at firſt to be only a Spirit impregnated with much of that Salt: at laſt came a very thick fetid Oil.

In this brown liquor, which comes off towards the end of the diſtillation, Mr. Homberg affirms the Acid to be contained; but, as it certainly is replete with a Volatile Alkali alſo, he alledges that it contains at the ſame time both a Volatile Alkali and the animal Acid; that theſe two Salts are diſtinct from each other, and not combined together in the form of an Ammoniacal Salt; that each of conſequence poſſeſſes its peculiar properties; and that this liquor is at the ſame time both Acid and Alkaline; that it efferveſces with Acids, and alſo changes the blue colours of plants to red.

The Alkaline quality of this liquor is very evident, and diſcovers itſelf in every Chymical trial; but the ſame cannot be ſaid of its Acid property. I dropped ſome of it on blue paper, the colour of

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* Memoirs of the Academy of Sciences for 1712.

which

which did not at firſt change in the leaſt, nor acquire the fainteſt ſhade of redneſs. This experiment almoſt determined me to conclude that Mr. Homberg was miſtaken: but ſome time afterwards I perceived that the blue paper began to turn red where it had been wetted, and that the red colour grew deeper and deeper as the paper dried: and this convinced me that this liquor actually contains an Acid, as Mr. Homberg aſſerted; but, that the Volatile Alkali in this liquor, being much more copious than the Acid, had firſt entered the paper, and hindered the Acid from turning it red as uſual; and that, as the Alkali evaporated, the Acid began to act and produce the cuſtomary effect. Hence we ſee that the Acid of Blood, though extricated by diſtillation, is not eaſily perceived at firſt, becauſe of the great proportion of Volatile Alkali with which the liquor containing it is impregnated. This is probably what prevented its being diſcovered by ſeveral Chymiſts, who, it ſeems, did not expect its exiſtence, and therefore did not look for it.

Mr. Homberg took no notice of this little difficulty in his Memoir: but he relates an experiment which might have given occaſion to ſuſpect it. It is in his analyſis of Human Blood. As the Acid in Human Blood is in leſs quantity, and leſs perceptible, than in the Blood of animals that live wholly on vegetables, he directs a ſecond diſtillation of the brown liquor, which contains at once both the Volatile Alkali and the Acid, till very little thereof be left in the retort. *This reſiduum,* ſays he, *contains a very perceptible and diſtinct Acid.* There is reaſon to believe, from Mr. Homberg's directing the ſaline liquor to be diſtilled again, that he did not find the Acid ſufficiently perceptible in it at firſt. Now a ſecond diſtillation is a very good way to render it much more ſenſible. For though this animal Acid be volatile, the Volatile Alkali is ſtill vaſtly more ſo; ſo that, if the liquor containing both theſe ſaline ſubſtances be diſtilled, the Volatile Alkali muſt needs riſe firſt, and leave the Acid alone, or almoſt alone, at the bottom of the retort. This is exactly the caſe in our experiment on blue paper; the operation being here performed with a ſmall quantity, and much more expeditiouſly, as appears from the account here given.

It is not at all ſurpriſing that the Volatile Alkali and animal Acid, though confounded together in the ſame liquor, ſhould not be united together and converted into a Neutral Ammoniacal Salt. Mr. Homberg pretends that theſe two ſaline matters do not act upon each other, becauſe they are too much dephlegmated. The oily parts, with which they are both loaded, may alſo contribute thereto: nor is this unprecedented; the ſame thing being obſerved of the Acid and the Volatile Alkali of ſeveral vegetable ſubſtances.

Mr. Homberg, juſtly ſuſpecting that there might be ſome difference between the condition of the Acid in the Blood of animals that feed altogether on vegetables, and that in the Blood of thoſe that feed only on fleſh, examined likewiſe by decompoſition the Blood and the fleſh of ſome carnivorous animals. In theſe alſo he found an Acid; and it doth not appear that he obſerved any great difference, in this reſpect, between their Blood and that of other animals. The difference he found between the Blood of young, and that of grown, or old, animals, with reſpect to the Acid, ſeems, by his account, to be more conſiderable; the Blood of the former containing much more of it than that of the latter: and this is ſo much the more probable, as we know that the fleſh of young animals grows ſour, before it putrefies, more ſenſibly than that of old ones.

We ſhall conclude this head with a remark concerning the management required in diſtilling

Blood. When the operation is advanced to a certain point, the matter contained in the retort often ſwells ſo as to ſtop the neck of that veſſel entirely, and by that means makes it burſt with an exploſion. To avoid this inconvenience, a very ſmall quantity of Blood muſt be put into the retort, and the fire muſt be governed very warily. I have alſo found that this accident may generally be prevented by mixing the Blood with ſome matter that can afford no principle by diſtillation; ſuch as pounded glaſs or fine ſand.

PROCESS II.

Fleſh analyzed. Inſtanced in Beef.

INTO an alembic or retort, placed in a ſand-bath, put ſome lean Beef, from which you have carefully ſeparated all the fat. Diſtill till nothing more will riſe. In this firſt diſtillation a phlegm will come over, weighing at leaſt half the maſs of the diſtilled fleſh. In the retort you will find a matter almoſt dry, which you muſt afterwards diſtill with a naked fire in a reverberating furnace, taking the uſual precautions. There will come over at firſt a little phlegm replete with Volatile Alkali; then a Volatile Alkali in a dry form, which will ſtick to the ſides of the veſſel; and alſo a thick Oil. After the diſtillation there will be left in the retort a black, ſhining, light coal. Burn it to aſhes in the open air, and lixiviate thoſe aſhes: the water of the lixivium will have no Alkaline property, but will ſhew ſome tokens of its containing a little Sea-ſalt.

OBSERVATIONS.

THIS analyſis of Beef is taken from a Memoir given in by Mr. Geoffroy in 1730, the purpoſe of which was a Chymical examination of the meat commonly uſed to make broth. The fleſh of an animal, as appears from the proceſs, yields much the ſame principles with its Blood : and it cannot be otherwiſe ; becauſe it is formed all together of materials furniſhed by the Blood.

Mr. Geoffroy obſerves that the firſt phlegm, drawn off from it in the *balneum mariæ*, produces a white precipitate in a ſolution of Corroſive Sublimate ; which ſhews it to contain a little Volatile Alkali : but the quantity thereof muſt be very ſmall, ſeeing the phlegm that contains it ſmells only like broth, and not like a Volatile Alkali, one particle of which, we know, is capable of affecting the organ of ſmelling very ſenſibly. As to the Acid of fleſh, there is great reaſon to believe that it is conditioned exactly like that of Blood.

The aſhes of the *caput mortuum* of fleſh burnt in an open fire attract the moiſture of the air, as Mr. Geoffroy remarks, and increaſe in weight, though they contain no Fixed Alkali. However, this is not at all ſurpriſing, ſince they contain ſome Sea-ſalt, the known property whereof is to grow moiſt in the air.

The fleſh of animals contains much matter that is ſoluble in water. Mr. Geoffroy examined ſeparately that part of fleſh which water is capable of diſſolving. With this view he boiled four ounces of beef with three pints of water, in a very cloſe veſſel, and repeated the operation ſix times with equal quantities of freſh water ; in order to extract, as far as poſſible, all the juices of the meat. Theſe broths he put all together, the laſt of them having but a faint ſmell of very weak veal-broth : he evaporated them over a ſlow fire, filtering them towards the end of the evaporation, to ſeparate an earthy part ; and there remained in the veſſel a moderately ſolid extract, which ſoon grew moiſt in the air. This extract being analyzed yielded a dram and two grains of Volatile Salt, which adhered to the ſides of the receiver; not in ramifications as Volatile Salts uſually do, but in flat cryſtals, moſtly in the form of parallelopipeds. The Spirit and the Oil, which came over together after the Volatile Salt, weighed thirty eight grains. Salt of Tartar being mixed with this Volatile Salt ſeemed to increaſe its ſtrength; which gives room to ſuſpect that the latter contains an Ammoniacal Salt.

The charred matter left in the retort weighed but ſix grains. Its lixivium gave ſome tokens of Sea-ſalt, by making a white precipitate in a ſolution of quick-ſilver. The maſs of fleſhy fibres that was exhauſted by boiling, being dried and analyzed in the ſame manner, yielded a Volatile Spirit, a Volatile Salt in a concrete form, which ſtuck to the ſides of the receiver in ramifications as uſual; and a thick fetid Oil. There now remained in the retort a charred matter, which being burnt in the open air, or not burnt, ſhewed not the leaſt ſign of its containing any ſaline matter.

This method of analyzing fleſh, by boiling it at firſt in water, in order to extract all that can be diſſolved by this menſtruum, ſhews us that animal fleſh contains an Oil which is in a ſaponaceous ſtate: for the extract made therefrom by water yields in diſtillation a conſiderable quantity of Oil, which was perfectly diſſolved in the water while that extract was in the diluted ſtate of broth, and before it was analyzed.

It is remarkable that the Volatile Salt yielded by the extract of fleſh is different from that which is obtained out of the fleſh itſelf when nothing hath been extracted from it. This Salt, as Mr. Geoffroy obſerved, differs from the common Volatile Alkalis in the form of its cryſtals; which made that Chymiſt juſtly conſider it as a Salt of a ſomewhat Ammoniacal nature, a kind of Eſſential Salt of fleſh.

There is reaſon to think that this Salt, when diſſolved in the water in which we boil fleſh, is ſeparated therefrom, by the action of fire, with more eaſe than while it remains combined with the other principles in the ſubſtance of the fleſh; that its ſeparation, in the latter caſe, requiring a greater degree of heat, it is thereby decompoſed; and that the Volatile Alkali, which is obtained from fleſh diſtilled in the uſual manner, is only one of the parts that conſtituted the Ammoniacal Salt thereby decompoſed.

The charred matter remaining, after the diſtillation of fleſh firſt exhauſted by boiling, yields nothing ſaline; becauſe the Sea-ſalt, which is the only Fixed Salt it could contain, was diſſolved by the water together with the matter of the extract.

Mr. Geoffroy likewiſe examined what parts of fleſh Spirit of Wine is capable of diſſolving. For this purpoſe he took four ounces of Beef dried in the *balneum mariæ*, poured on it an equal weight of well rectified Spirit of Wine, and left the whole in digeſtion for a conſiderable time. The Spirit extracted from the Beef a weak tincture, and ſeparated from it ſome drops of Oil: it acquired a brown colour, and a faint ſmell. Mr. Geoffroy found, by ſeveral experiments, that the Spirit of Wine had taken up a portion of the Ammoniacal or Eſſential Salt of the fleſh. With reſpect to the Oil, if any at all were diſſolved, it could be but very little; for that which the Spirit ſeparated, and which retained its natural form, was certainly not diſſolved: ſeeing in that caſe it would not have been perceived, but would have made a homogeneous liquor, to appearance, with the Spirit of Wine.

PROCESS III.

Bones analyzed. Inſtanced in Ox-bones.

CUT into pieces the Bones of a leg of beef, carefully ſeparating all the marrow. Put them into a retort, and diſtill them in a reverberating furnace as uſual. A phlegm will come over firſt; then a Volatile Spirit, which will become ſtronger and ſtronger; afterwards a Volatile Salt in a dry form, with ſome Oil; and, laſtly, a black Oil, with a little more Volatile Salt. There will be left in the retort a charred matter, from which a little Sea-ſalt may be extracted. Reduce this charred matter to aſhes, by burning it in the open air. Theſe aſhes will give ſome ſlight tokens of a Fixed Alkali.

OBSERVATIONS.

THE analyſis of Bones proves that they conſiſt of the ſame principles with fleſh and blood; and the ſame may be ſaid, in general, of all matters that are truly animal, that actually conſtitute any part of an animal.

Nevertheleſs we find in the aſhes of Bones ſomewhat of an Alkaline quality; ſeeing they make a red precipitate in a ſolution of Corroſive Sublimate; and yet a true Fixed Alkali cannot be obtained from them. Theſe aſhes are probably in the ſame caſe with quick-lime; which hath certain properties of Alkaline Salts, though no Salt of that kind can be extracted from it.

Mr. Geoffroy analyzed Bones in the ſame manner as he did fleſh; that is, he at firſt made a ſtrong decoction of them with water, and then examined and diſtilled apart the extract afforded him by that decoction, and the Bones deprived of that extract. On this analyſis he made two remarkable obſervations.

The firſt is that Bones yielded to boiling water their principles and their Volatile Salts, both ſooner and more copiouſly than fleſh did: for in the analyſis which Mr. Geoffroy made of ſeveral ſorts of fleſh, though he robbed them in a manner of all their principles by boiling, yet their dried fibres afterwards yielded a conſiderable quantity of Volatile Salt; whereas the Bones, of which he had made an extract by boiling, afforded him but a very ſmall quantity thereof when analyzed.

The ſecond obſervation worthy of notice which Mr. Geoffroy made on his analyſis of Bones is this; the Salt, which, as was ſhewn in the analyſis of fleſh, was reſolved by the water wherein he boiled the fleſh, and conſequently roſe when he diſtilled the extract obtained from that decoction, and cryſtallized in the form of parallelopipeds, took a quite different turn in the analyſis of Bones. None of it appeared in diſtilling the extract made by decoction, but roſe in diſtilling the boiled Bones, that were exhauſted of almoſt all their other principles by the decoction with water. Theſe differences probably ariſe from the different contexture of the animal matters in which they are obſerved.

This analyſis of Bones may ſerve as a pattern for analyzing all the ſolid parts of animals, ſuch as horns, hoofs, ivory, &c.

PROCESS IV.

Animal Fat analyzed. Inſtanced in Mutton-Suet.

PUT as much Mutton-Suet as you pleaſe into a glaſs retort, only taking care that the veſſel be but half full; and diſtill with degrees of fire as uſual. A phlegm ſmelling of the Suet will riſe firſt, and ſoon grow very acid. After this ſome drops of Oil will come over, and be followed by a matter like Oil, in appearance, when it comes over; but it will fix in the receiver, and acquire a conſiſtence ſomewhat ſofter than Suet. This kind of Butter of Suet will continue to riſe to the end of the diſtillation; and there will be left in the retort a ſmall quantity of charred matter.

OBSERVATIONS.

THOUGH animal Fat be a ſubſtance that hath paſſed through all the ſtrainers of the body; though it hath undergone all the elaborations neceſſary to form an animal matter, and become itſelf part of the animal; it contains nevertheleſs, as its analyſis ſhews, principles differing greatly from thoſe of all other animal matters: ſo that it muſt be claſſed, in ſome ſort, by itſelf.

It conſiſts almoſt entirely of Oil: but this Oil is in a concrete form, and obſerves the general rule of all concreted oily matters, which owe their conſiſtence wholly to the Acid that is combined with them. The rule is evidently ſo general that it extends even to the animal kingdom, where, in all other inſtances, Acids ſeem to be almoſt annihilated.

All we ſaid above on the ſubject of Butter muſt be applied here: for animal Fat, properly ſo called, and Butter, do not, in my opinion, differ ſenſibly from each other, with reſpect to their analyſis. And therefore there is great reaſon to believe that what is Butter in Chyle, or Milk, becomes Fat when fixed in the animal body. It is a kind of repoſitory in which nature lays up and confines the Acid that is unneceſſary to the animal compoſition, and which ſhe could not any other way eliminate.

I made choice of Mutton-Suet for an inſtance of the analyſis of Fat; becauſe this Fat, being the firmeſt of any, muſt contain a ſtronger and more perceptible Acid.

When it is thus diſtilled, the part which remains fixed hath much leſs conſiſtence than the Suet had before; which ariſes from its having loſt part of its Acid. Repeated diſtillations will deprive it of a much greater quantity thereof, and ſo reduce it into an Oil that will always remain clear and fluid.

Not one particle of Volatile Alkali is obtained by diſtilling Suet: but then the experiment will not ſucceed as it ought, unleſs care be taken to free the Suet perfectly from all the membranes, and all the particles of fleſh and blood that may be mixed with it; for, if it ſhould be diſtilled without this precaution, thoſe heterogeneous matters mingled with it would yield a great deal of Volatile Alkali in diſtillation; which might impoſe on the Artiſt, and make him think the Salt came actually from the Suet. Suet that hath been often melted, as the tallow, for inſtance, of which candles is made, is ſufficiently purified: of this I made uſe in my analyſis and it yielded me no Volatile Alkali; at leaſt I could perceive none.

In concluſion, all that hath been ſaid, on ſeveral occaſions, touching the properties of concreted oily matters, may be applied to Suet. I ſhall only obſerve here that it is one of thoſe that manifeſt no Acidity, and conſequently that in its natural ſtate it is not ſoluble in Spirit of Wine, and only becomes ſoluble in that menſtruum by degrees as its

Acid is extricated by repeated diſtillations: and on this account it ought to be claſſed with Bee's-Wax, and other oily compounds of that kind.

PROCESS V.

Eggs analyzed. Inſtanced in Pullet's Eggs.

PUT ſome Hen's Eggs in water, and boil them till they be hard. Then ſeparate the Yelks from the Whites. Cut the Whites into little bits; put them into a glaſs cucurbite; fit on a head and receiver; diſtill in a *balneum mariæ* with degrees of fire, raiſing it towards the end to the ſtrongeſt heat which that bath can give; that is, to the heat of boiling water. There will come over an aqueous liquor, or inſipid phlegm; the quantity whereof will be very conſiderable, ſeeing it will make about nine tenths of the whole maſs of the Whites of the Eggs. Continue your diſtillation, and keep the water in the bath conſtantly boiling, till not a drop more of liquor will aſcend from the alembic. Then unlute your veſſels. In the cucurbite you will find your Whites of Eggs conſiderably ſhrunk in their bulk. They will look like little bits of brown glaſs, and be hard and brittle.

Put this reſiduum into a glaſs retort, and diſtill, as uſual, in a reverberating furnace with degrees of heat. There will come over a Volatile Oily Spirit, a yellow Oil, a Volatile Salt in a dry form, and, at laſt, a black thick Oil. There will be left in the retort a charred matter.

Reduce alſo into the ſmalleſt pieces you can the hard Yelks of the Eggs which you ſeparated from the Whites. Set them in a pan over a gentle fire: ſtir them with a ſtick till they turn a little brown, and diſcharge a ſubſtance like melted marrow.

Then put them into a new ſtrong canvaſs bag and preſs them between two iron plates well heated; whereby you will obtain a conſiderable quantity of a yellow Oil.

Let what remains in the bag be diſtilled in a retort ſet in a reverberating furnace: it will give you the ſame principles as you got from the Whites.

OBSERVATIONS.

OF the two perfectly diſtinct ſubſtances that conſtitute the Egg, the Yelk contains the embryo of the chick, and is deſtined to hatch it: the White is to ſerve for the nouriſhment of the chick when it is formed.

Theſe two matters, though they contain the very ſame principles, yet differ conſiderably from each other; and chiefly in this, that their principles are not in the ſame proportions.

The White of an Egg contains ſo much phlegm, that it ſeems to conſiſt almoſt totally thereof. All the aqueous liquor, obtained by diſtilling it in the *balneum mariæ*, is, properly ſpeaking, nothing but pure water; for no Chymical trial can diſcover in it either an Acid or a Volatile Alkali; or any very perceptible Oily part. And yet it muſt contain ſome Oil, becauſe the liquor that riſes laſt is a little bitteriſh to the taſte, and ſmells ſomewhat of empyreuma. But the principles from which it derives theſe properties are in too ſmall quantities to be diſtinctly perceived.

If, inſtead of diſtilling the hard White of an Egg, with a view to draw off the great quantity of water it contains, you leave it ſome time in an air that is not too dry, the greateſt part of its moiſture ſeparates ſpontaneouſly, and becomes very ſenſible. In all probability this is the effect of a beginning putrefaction, which attenuates this ſubſtance, and breaks its contexture. The liquor thus diſcharged by the White of an Egg thoroughly diſſolves the Gum-Reſins, and particularly Myrrh. If you deſire to diſſolve Myrrh in this manner, cut a hard-boiled Egg in halves; take out the Yelk; put the powdered Gum-Reſin into the cavity left by the Yelk; join the two halves of the White; faſten them together with a thread, and hang them up in a cellar. In a few days time the Myrrh will be diſſolved by the moiſture that iſſues from the White of the Egg, and will drop into the veſſel placed underneath to receive it. This liquor is improperly called *Oil of Myrrh per deliquium*.

All the properties of the Whites of Eggs, as well as the principles obtained by analyzing them, are the ſame with thoſe of the lymphatic part of the blood; ſo that there is a great reſemblance between theſe two ſubſtances.

As to the Yelk, it is plain from its analyſis that Oil is the predominant principle thereof. If the Yelk of an Egg be mixed with water, the Oil with which it is replete, and which is by nature very minutely divided, diffuſes eaſily through the whole liquor, and remains ſuſpended therein by means of its viſcoſity. The liquor at the ſame time becomes milk-white like an emulſion, and is in fact a true animal emulſion.

In order to obtain the Oil of Eggs by expreſſion with the more eaſe, care muſt be taken to chuſe Eggs that are ſeven or eight days old; becauſe they are then a little leſs viſcous. Nevertheleſs their viſcoſity is ſtill ſo great that they will not eaſily yield their Oil by expreſſion: and therefore, in order to attenuate and deſtroy entirely this viſcoſity, they muſt be torrefied before they are put to be preſſed.

The Oil of Eggs, like all other oily animal matters, ſeems analogous to the Fat Oils of vegetables. It hath all the properties that characterize thoſe

Oils. Its colour is yellow, and it ſmells and taſtes a little of the empyreuma, occaſioned by torrefying the Yelks. It is rendered ſomewhat leſs diſagreable by being expoſed to the dew for thirty or forty nights, if care be taken to ſtir it often in the mean time.

To conclude: all the principles both in the Yelk and the White of an Egg are the ſame as thoſe found in Blood, Fleſh, and all other matters that are perfectly animal.

CHAP. III.

OF THE EXCREMENTS OF ANIMALS.

PROCESS I.

Dung analyzed. Inſtanced in Human Excrement. Mr. Homberg's Phoſphorus.

TAKE any quantity you pleaſe of human Excrement, and diſtill it in a glaſs alembic ſet in the *balneum mariæ*. You will obtain an aqueous, clear, inſipid liquor; which will nevertheleſs have a diſagreable odour. Having urged the diſtillation as far as is poſſible with the heat of this bath, unlute your veſſels, and you will find at the bottom of the cucurbite a dry matter, making about an eighth part only of what you put into it. Put this reſiduum into a glaſs retort, and diſtill in a reverberating furnace, with degrees of heat. You will obtain a Volatile Spirit, and a Volatile Salt, with a fetid Oil; and a charred matter will be left in the retort.

OBSERVATIONS.

Mr. Homberg made a great many experiments on the dung of animals; concerning which he compoſed two Memoirs publiſhed in the Academy's collection for 1711. That Chymiſt tells us, that, in diſtilling Excrement, he aimed not ſo much at diſcovering the principles of which it conſiſts, as he was deſirous to ſatisfy a friend of his, who had earneſtly entreated him to try whether he could not extract therefrom a clear Oil, having no bad ſmell; becauſe he had ſeen, as he ſaid, Mercury fixed into pure Silver by ſuch an Oil.

Mr. Homberg's labour had the uſual fate of all enterpriſes of this nature. He actually found the art of drawing from Excrement a clear ſcentleſs Oil; but, in whatever way he applied it to Mercury, it produced no change in that metallic ſubſtance. However, as Mr. Homberg was a man of ſagacity, and knew how to improve every hint offered by his experiments, he made ſeveral curious diſcoveries on this occaſion; of which we ſhall give a conciſe account, after we have made ſome remarks on the principles obtained from Excrement by the method deſcribed in the proceſs.

This ſubſtance, conſiſting of matters ſubject to putrefaction, hath conſtantly a fetid ſmell, like that of all putrid matters; having been for ſome time confined in a warm, moiſt place, which we know promotes putrefaction, and even quickly produces it. Yet the analyſis thereof proves that it is not putrefied, or at leaſt not entirely ſo: for all putrefied matters contain a Volatile Alkali perfectly formed and extricated; and, as this principle riſes with leſs heat than that of boiling water, it always comes over firſt in diſtillation. Now we have ſeen that, with the heat of boiling water, it parts with nothing but an inſipid phlegm, containing no Volatile Alkali: a ſure proof that the fecal matter is not completely putrefied.

There is nothing remarkable in the Volatile Salt and fetid Oil, which riſe with a degree of heat greater than that of boiling water. They are common productions, of which we have made frequent mention in ſeveral of the preceding analyſes; and therefore they need not now detain us from proceeding to give a ſummary account of Mr. Homberg's chief diſcoveries.

One of the methods by which Mr. Homberg endeavoured to obtain from Excrement a clear Oil, without any bad ſmell, was to ſeparate its earthy and groſs parts, by filtering it before he diſtilled it. "For this purpoſe he diluted Excrement newly "diſcharged with hot water, uſing a quart of wa-"ter to an ounce of feces. Then he let the mix-"ture ſtand to cool, and, the groſs parts falling to "the bottom, he poured off the water by inclina-"tion. This liquor he filtered through brown "paper, and evaporated to a pellicle over a gentle "fire. There ſhot in it long cryſtals of four, five, "and ſix ſides, which Mr. Homberg thinks may "be called the Eſſential Salt of Excrement. They "reſemble Salt-petre, in ſome meaſure, and de-"flagrate in the fire much like it; with this differ-"ence that their flame is red, and they burn ſlowly; "whereas the flame of Salt-petre is white and very "vivid: probably, ſays Mr. Homberg, becauſe "there is too much of an oily matter in the one, "and leſs in the other.

"Mr. Homberg diſtilled this Salt in a glaſs "retort with degrees of fire, and at laſt with a "very violent one. At firſt there came over an "aqueous liquor, ſharp and acid, which was fol-"lowed by a brown fetid oil, ſmelling very ſtrong "of empyreuma. This diſtillation he attempted "four ſeveral times; and each time the matter in "the retort took fire, juſt when the Oil began to "come off."

The Salt which Mr. Homberg obtained from Excrement is very remarkable. We ſhall have occaſion to ſpeak of it in another place, and ſhall only obſerve here that its Nitrous character is by no means ambiguous: its deflagrating on live coals convinced Mr. Homberg of its being a true Nitre. But its conſtantly taking fire in the retort, as oft as diſtilled, is a ſure proof that it is a Nitrous Salt: for Nitre only hath the property of thus taking fire in cloſe veſſels, and making other combuſtible matters burn along with it.

The proceſs by which Mr. Homberg at laſt obtained from Excrement a clear oil without any bad ſmell is curious, and worthy of a place here; on account of the views and occaſions of reflection which it may open.

"Mr. Homberg having tried in vain, by diſtilling Excrement a great many different ways, "to obtain from it ſuch an Oil as he wanted, reſolved to employ fermentation, the effect whereof "is to change the diſpoſition of the principles of "mixts. With this view he dried ſome Excrement in the water-bath, and, having pulverized "it, poured thereon ſix times its weight of "phlegm that had been ſeparated from it by diſtillation, and put the whole into a large glaſs cucurbite, covered with an inverted veſſel that "fitted exactly into it, and was cloſe luted. This "veſſel he ſet in a *balneum mariæ* for ſix weeks, "keeping up ſuch a gentle heat as would not burn "one's hand; after which he uncovered the cucurbite, and having fitted thereto a head and a "receiver, diſtilled off all the aqueous moiſture "in the *balneum mariæ* with a very gentle heat. "It had now loſt almoſt all its bad ſmell, which "was changed into a faint one. It came over

" ſomewhat turbid, whereas it was very clear when " put into the cucurbite. Mr. Homberg found " this water to have a coſmetic virtue: He gave " ſome of it to perſons whoſe complexion, neck, " and arms, were quite ſpoiled, being turned " brown, dry, rough, and like a gooſe ſkin: " they waſhed with it once a day, and, by con-" tinuing the uſe of this water, their ſkin became " very ſoft and white."

The dry matter, that remained in the bottom of the cucurbite after diſtillation, had loſt about a twentieth part of its weight; that is, of twenty ounces, put at one time into the cucurbite, ſomewhat leſs than nineteen ounces remained. Mr. Homberg ſuſpects that it was not ſo dry when put into the cucurbite as when it was taken out. Perhaps alſo the ſpecies of fermentation which the matter underwent had attenuated and volatilized ſome part of it; ſo that it came over with the phlegm in diſtillation. The turbidneſs of that phlegm, which was clear and limpid before, ſeems to countenance this conjecture.

" The dry matter left in the cucurbite after the " firſt diſtillation, had not the leaſt ſmell of feces: " on the contrary, it had an agreable aromatic " odour; and the veſſel in which Mr. Homberg " had digeſted it, being left open in a corner of " his laboratory, acquired in time a ſtrong ſmell " of Ambergris. It is ſurpriſing, as Mr. Hom-" berg juſtly obſerves, that digeſtion alone ſhould " change the abominable ſmell of Excrement into " an odour as agreeable as that of Ambergris.

" This dry matter he powdered coarſely, and " put two ounces thereof at once into a glaſs re-" tort that would hold about a pound or a pound " and half of water. This he diſtilled in a ſand-" bath with a very gentle heat. A ſmall quantity " of an aqueous liquor came over firſt, and then

" an Oil as colourleſs as ſpring-water. Mr. Homberg continued the ſame gentle degree of heat " till the drops began to come off a little rediſh ; " and then he changed the receiver, ſtopping that " which contained the clear Oil very cloſe with a " cork. Having carried on the diſtillation with " a fire gradually augmented, there came over a " conſiderable quantity of red Oil ; and there remained in the retort a charred matter which burnt " very readily."

The clear Oil, without any ill ſmell, which Mr. Homberg obtained from the fecal matter by this proceſs, was the very thing he was in ſearch of, and which he had been aſſured would convert Mercury into fine fixed Silver: yet he ingenuouſly owns, that, whatever way he applied it, he could never produce any change in that metallic ſubſtance. We ſhall now proceed to the other diſcoveries made by Mr. Homberg on this occaſion.

In his attempt to obtain a clear Oil from Excrement, he diſtilled it with different additaments, and amongſt the reſt with Vitriol and Alum. He found that the matters left in the retort, when he made uſe of theſe Salts, being expoſed to the open air, took fire of themſelves ; that they kindled combuſtible matters ; in a word, that they were a true Phoſphorus, of a ſpecies different from all then known. Purſuing theſe firſt hints, he ſought and found the means of preparing this Phoſphorus by a way much more expeditious, certain, and eaſy. His proceſs is this.

" Take four ounces of Feces newly excreted: " Mix therewith an equal weight of Roch-Alum " coarſely powdered : put the whole into a little " iron pan that will hold about a quart of water, " and ſet it over a gentle fire under a chimney. " The mixture will melt, and become as liquid as " water. Let it boil with a gentle fire, conſtantly

“ ſtirring it, breaking it into little crumbs, and ſcraping off with a ſpatula whatever ſticks to the bottom or ſides of the pan, till it be perfectly dry. The pan muſt from time to time be removed from the fire, that it may not grow red-hot, and the matter muſt be ſtirred, even while it is off the fire, to prevent too much of it from ſticking to the pan. When the matter is perfectly dried, and in little clots, let it cool, and powder it in a metal mortar. Then put it again into the pan, ſet it over the fire, and ſtir it continually. It will again grow a little moiſt, and adhere together in clots, which muſt be continually roaſted and bruiſed till they be perfectly dry; after which they muſt be ſuffered to cool, and then be pulverized. This powder muſt be returned a third time to the pan, ſet on the fire, roaſted and perfectly dried: after which it muſt be reduced to a fine powder, and kept in a paper in a dry place. This is the firſt or preparatory operation.

“ Take two or three drams of this powder. Put it into a little matraſs, the belly of which will hold an ounce, or an ounce and half of water, and having a neck about ſix or ſeven inches long. Order it ſo that your powder ſhall take up no more than about a third part of the matraſs. Stop the neck of the matraſs ſlightly with paper: then take a crucible four or five inches deep: in the bottom of the crucible put three or four ſpoonfulls of ſand: ſet the matraſs on this ſand, and in the middle of the crucible, ſo as not to touch its ſides. Then fill up the crucible with ſand, ſo that the belly of the matraſs may be quite buried therein. This done, place your crucible with the matraſs in the midſt of a little earthen furnace, commonly called a *Stove*, about eight or ten inches wide above,

" and ſix inches deep from the mouth to the grate. " Round the crucible put lighted coals about half " way up, and when it hath ſtood thus half an " hour, fill up with coals to the very top of the " crucible. Keep up this fire a full half-hour " longer, or till you ſee the inſide of the matraſs " begin to be red. Then increaſe your fire, by " raiſing your coals above the crucible. Continue " this ſtrong heat for a full hour, and then let the " fire go out.

" At the beginning of this operation denſe fumes " will riſe out of the matraſs, through the ſtopple " of paper. Theſe fumes iſſue ſometimes in ſuch " abundance as to puſh out the ſtopple; which you " muſt then replace, and ſlacken the fire. The " fumes ceaſe when the inſide of the matraſs be- " gins to grow red; and then you may increaſe " the fire without any fear of ſpoiling your opera- " tion.

" When the crucible is ſo cold that it may be " ſafely taken out of the furnace with one's hand, " you muſt gradually draw the matraſs out of the " ſand, that it may cool ſlowly, and then ſtop it " cloſe with a cork.

" If the matter at the bottom of the matraſs " appear to be in powder when ſhaken, it is a ſign " the operation hath ſucceeded: but if it be in a " cake, and doth not fall into powder on ſhaking " the matraſs, it ſhews that your matter was not " ſufficiently roaſted and dried in the iron pan, " during the preparatory operation."

Since Mr. Homberg, Mr. Lemeri the younger hath made a great many experiments on this Phoſphorus, which may be ſeen in the Memoirs of the Academy for 1714 and 1715. In thoſe Memoirs Mr. Lemeri hath ſhewn that Excrement is not the only matter capable of producing this Phoſphorus with Alum; but that, on the contrary, almoſt all animal and even vegetable matters are fit for this combination; that though Mr. Homberg mixed Alum in equal quantities only with the fecal matter, it may be uſed in a much greater proportion, and, in certain caſes, will ſucceed the better; that, according to the nature of the ſubſtances to be worked on, the quantity of that Salt may be more or leſs increaſed; and that whatever is added, more than the doſe requiſite for each matter, ſerves only to leſſen the virtue of the Phoſphorus, or even deſtroys it entirely; that the degree of fire applied muſt be different according to the nature of thoſe matters; and, laſtly, that Salts containing exactly the ſame Acid with that of Alum, or the Acid of thoſe Salts ſeparated from its baſis and reduced into Spirit, do not anſwer in the preſent operation: which ſhews, ſays Mr. Lemeri, that many ſulphureous matters may be ſubſtituted for Excrement in this operation; but that there are no Salts, or very few if any, that will ſucceed in the place of Alum. Neverthelеſs a Chymiſt, who lately communicated to the Academy a great number of experiments on this Phoſphorus, found that any Salt containing the Vitriolic Acid may be ſubſtituted for Alum.

This Phoſphorus, made either by Mr. Homberg's or by Mr. Lemeri's method, ſhines both by day and by night. Beſides emitting light, it takes fire ſoon after it is expoſed to the air, and kindles all combuſtible matters with which it comes in contact; and this without being rubbed or heated.

Meſſ. Homberg and Lemeri have given the moſt probable and the moſt natural explanation of the cauſe of the accenſion and other phenomena of this Phoſphorus. What they ſay amounts in ſhort to what follows.

Alum is known to be a Neutral Salt, conſiſting of the Vitriolic Acid and a calcareous earth. When this Salt is calcined with the fecal matter, or other ſubſtances abounding in Oil, the volatile principles of theſe ſubſtances, ſuch as their Phlegm, their Salts, and their Oils, exhale in the ſame manner as if they were diſtilled; and there is nothing left in the matraſs, when thoſe principles are diſſipated, but a charred matter, like that which is found in retorts wherein ſuch mixts have been decompoſed by diſtillation.

This remainder therefore is nothing but a mixture of Alum and charcoal. Now as the Acid of this Salt, which is the Vitriolic, hath a greater affinity with the phlogiſton than with any other ſubſtance, it will quit its baſis to unite with the phlogiſton of the coal, and be converted by that union into a Sulphur. And this is the very caſe, of which we have certain proofs in the operation for preparing this Phoſphorus: for when, after the volatile principles of the oily matter are drawn off, the fire is encreaſed, in order to combine cloſely together the fixed parts that remain in the matraſs, that is, the Alum and the charred matter, we perceive at the mouth of the matraſs a ſmall blue ſulphureous flame, and a pungent ſmell of burning Sulphur. Nay, when the operation is finiſhed, we find a real Sulphur ſticking in the neck of the matraſs; and, while the Phoſphorus is burning, it hath plainly a ſtrong ſulphureous ſmell. It is therefore certain that this Phoſphorus contains an actual Sulphur; that is, a matter diſpoſed to take fire with the greateſt eaſe. But though Sulphur be very inflammable, it never takes fire of itſelf, without being either in contact with ſome matter that is actually ignited, or elſe being expoſed to a conſiderable degree of heat. Let us ſee then what may be the cauſe of its accenſion, when it is a conſtituent part of this Phoſphorus.

We mentioned juſt now that the Acid of the Alum quits its baſis, in order to form a Sulphur by combining with the Phlogiſton of the coal. This baſis we know to be an earth capable of being converted into Lime; and that it is actually converted into Quick-lime by the calcination neceſſary to produce the Phoſphorus. We know that new-made Lime hath the property of uniting with water ſo readily, that it thereby contracts a very great degree of heat. Now when this Phoſphorus, which is partly conſtituted of the baſis of the Alum converted into Quick-lime, is expoſed to the air, the Lime inſtantly attracts the moiſture of which the air is always full, and by this means, probably, grows ſo hot as to fire the Sulphur with which it is mixed. Perhaps alſo the Acid of the Alum is not totally changed into Sulphur: ſome part thereof may be only half-diſengaged from its baſis, and in that condition be capable of attracting ſtrongly the humidity of the air, of growing very hot likewiſe by imbibing the moiſture, and ſo of contributing to the accenſion of the Phoſphorus.

There is alſo room to think that all the Phlogiſton of the charred matter is not employed in the production of Sulphur in this Phoſphorus, but that ſome part of it remains in the ſtate of a true coal. The black colour of the unkindled Phoſphorus, and the red ſparkles it emits while burning, ſufficiently prove this. The explanation of the accenſion of this Phoſphorus, as here given by Meſſ. Homberg and Lemeri, is very ingenious, and in the main juſt; but yet, in my opinion, the ſubject deſerves a more thorough examination.

PROCESS II.

Human Urine analyzed.

PUT ſome Human Urine into a glaſs Alembic; ſet it in a water-bath, and diſtill till there remain only about a fortieth part of what you put in; or elſe evaporate the Urine in a pan ſet in the *balneum mariæ* till it be reduced to the ſame quantity. With this heat nothing will exhale but an inſipid Phlegm, ſmelling however like Urine. The reſiduum will, as the evaporation advances, become of a darker and darker ruſſet, and at laſt acquire an almoſt black colour. Mingle this reſiduum with thrice its weight of ſand, and diſtill it in a retort ſet in a reverberating furnace, with the uſual precautions. At firſt there will come over a little more inſipid Phlegm like the former. When the matter is almoſt dry, a Volatile Spirit will riſe. After this Spirit, white vapours will appear on encreaſing the fire; a yellow oily liquor will come off, trickling down in veins; and together with this liquor a concrete Volatile Salt, which will ſtick to the ſides of the receiver. At laſt there will come over a deep-coloured fetid Oil. In the retort there will remain a ſaline earthy reſiduum, which being lixiviated will yield ſome Sea-ſalt.

OBSERVATIONS.

URINE muſt be conſidered as an aqueous liquor replete with all the ſaline matters which are of no uſe to the body, either for nouriſhment or health: it is a lixivium of animal matters, prepared by nature for diſſolving and ſeparating from them all the unneceſſary Salts. It contains a very large quantity of almoſt pure phlegm, which evaporates with the heat of a water-bath.

The reſidue of the Urine, from which this phlegm is ſeparated by the firſt diſtillation, though thereby rendered conſiderably thicker, doth not coagulate, or curdle in the leaſt like Milk or Blood; which ſhews that it contains no parts analogous to thoſe of theſe two nutritious liquors. Yet it contains oily and ſaline parts, diſpoſed like thoſe of truly animal matters; as appears from the Spirit, the Volatile Salt, and the Oil, obtained from it by diſtillation; which are, in every reſpect, perfectly like the ſame principles yielded by other animal ſubſtances. But, if the animal that made the Urine took in with its food any of the Neutral Salts which cannot be decompounded by digeſtion; that is, of thoſe chiefly which conſiſt of Acids and Alkalis, the Urine will contain, over and above the other parts of that animal, almoſt all the Neutral Salt that entered into its body. Accordingly human Urine is replete with a conſiderable quantity of Sea-ſalt, becauſe men eat a great deal of it. It is found, after the diſtillation of the Urine, united with the *caput mortuum* left in the retort; becauſe, being of a fixed nature, it doth not riſe with the volatile principles in diſtillation.

Beſides this Sea-ſalt, Urine contains another Salt of a ſingular nature, which cryſtallizes differently from Sea-ſalt. In this Salt, according to Mr. Marggraff's experiments mentioned on the ſubject of Phoſphorus, is contained the Acid neceſſary to produce the Phoſphorus of Urine. There is reaſon to think that this Salt is a Sea-ſalt diſguiſed by the fat matters with which it combines during its ſtay in the animal body.

Mr. Boerhaave calls it the Eſſential Salt of Urine. If you deſire to have it by itſelf, you muſt evaporate the Urine, with a gentle heat, to the conſiſtence of freſh cream, filter it, and let it ſtand quiet in a cool place. Cryſtals will at length ſhoot therein, and adhere to the ſides of the veſſel. Theſe cryſtals are the Salt you want: they are brown and oily. If you deſire to have them purer, you muſt diſſolve them in warm water, filter the ſolution, and ſet it by to ſhoot. This operation repeated ſeveral times will render them clear and tranſparent. Mr. Schloſſer, a young and very promiſing Chymiſt, is the laſt who hath made any experiments on this curious Salt of Urine. Thoſe who are deſirous of a particular account of its properties may conſult his diſſertation printed at Leyden in 1753, as well as Mr. Marggraff's excellent Memoirs printed among thoſe of the Academy of Berlin.

The chief reſult of Mr. Schloſſer's experiments is, firſt, that this Salt may be obtained from recent Urine, and even in greater quantities than from putrid Urine, and that too in very little time; ſeeing it cryſtallizes in twenty four hours, after due evaporation.

Secondly, that this Salt is a Neutral Ammoniacal Salt, conſiſting of a Volatile Alkali, (which can never be extracted from it but in a liquid form, like that which is ſeparated from Urine by the addition of Lime;) and of an Acid of a very ſingular nature, the moſt remarkable property of which is its being ſo fixed as to reſiſt the violence of fire, and turn into a ſort of glaſs rather than exhale in vapours. This is that Acid which, according to Mr. Marggraff's experiments, forms the combination of Phoſphorus when united with the Phlogiſton. The other properties of this ſingular Acid are the principal objects of Mr. Marggraff's enquiries.

It follows, in the third place, from Mr. Schloſſer's experiments that this Acid, being combined to the point of ſaturation with a common Volatile Alkali, forms a true, regenerated Salt of Urine; and that, by this union, the nature of the Volatile Alkali is ſo changed, that it cannot afterwards appear by itſelf in a concrete form, but is always fluid, like that which is extricated by the additament of lime.

If Fixed Alkalis be mixed with freſh Urine, they immediately ſeparate from it a Volatile Alkali; and if the mixture be quickly put into an alembic, and diſtilled, the firſt liquor that riſes is a Volatile Spirit: or elſe a Volatile Alkali in a concrete form will riſe firſt, provided the Fixed Alkali made uſe of be not liquid, and the Urine be dephlegmated.

Herein Urine reſembles other animal matters; for Fixed Alkalis produce the ſame effect on them. This affords us good grounds for believing that all animal matters contain a Neutral Salt of an Ammoniacal nature, which the Fixed Alkali decompoſes, as it doth all other Ammoniacal Salts. Quick-lime alſo extricates from Urine a Volatile Alkali ſtill more quick and pungent than that which is ſeparated by a Fixed Alkali, and which conſtantly remains liquid without ever putting on a concrete form: and this is another proof of the exiſtence of the Ammoniacal Salt above mentioned; for quick-lime hath juſt the ſame effect on Sal-Ammoniac, as we ſhall ſee in its place. Mr. Schloſſer's experiments, compared with thoſe now mentioned, ſeem to ſhew that the Urine contains ſeveral diſtinct ſorts of Ammoniacal Salts.

Of all the liquors which animals afford, Urine putrefies the moſt eaſily, and by putrefaction parts with or forms the greateſt quantity of Volatile Alkali. If it be diſtilled when putrefied, there comes over firſt a Spirit impregnated with much Volatile

Alkali; then an aqueous liquor, which Van Helmont aſſures us is a medicine of wonderful efficacy in diſſolving the ſtone in the bladder. When all this water is come over, and the remaining matter is almoſt dry, there aſcends, on increaſing the fire, a yellow Oil, together with a Volatile Salt.

After this there remains in the retort a black charred earthy matter, containing a great deal of Sea-ſalt. If this matter be calcined in the open air, in order to conſume its phlogiſton, and be afterwards lixiviated, all the Sea-ſalt it contains may by this means be eaſily ſeparated; nothing but its earth being left behind. This *caput mortuum* contains alſo the materials proper for forming Kunckel's Phoſphorus; and if, inſtead of calcining it in the open air, it be urged with a violent fire, in cloſe veſſels, it will yield a Phoſphorus: but then all the precautions recommended on the ſubject of Phoſphorus muſt be uſed; and, in particular, the *caput mortuum* muſt be lixiviated before it be diſtilled, in order to free it from part of the Sea-ſalt contained therein; becauſe too much of that Salt might defeat the operator, by not only melting itſelf, but melting alſo the containing veſſel during the operation.

CHAP.

CHAP. IV.

OF THE VOLATILE ALKALI.

PROCESS I.

Volatile Alkalis rectified and depurated.

MIX together the Spirit, the Volatile Salt, the Phlegm, and the Oil, obtained from any ſubſtance whatever. Put the whole into a large wide-mouthed glaſs body, and thereto fit a head with a large beak. Set this alembic in a water-bath, lute on a receiver, and diſtill with a very gentle heat. There will aſcend a Spirit ſtrongly impregnated with Volatile Alkali, and a Volatile Salt in a concrete form, which muſt be kept by itſelf. Then increaſe your heat to the degree of boiling water; whereupon there will riſe a ſecond Volatile Spirit, ſomewhat more ponderous than the former, with a light Oil that will ſwim on its ſurface, and a little concrete Volatile Salt. Proceed till nothing more will riſe with this degree of heat. Keep by itſelf what came over into the receiver. At the bottom of the cucurbite you will find a thick fetid Oil.

Into ſuch another diſtilling veſſel put the Spirit and Salt that roſe firſt in this diſtillation, and diſtill them in the *balneum mariæ* with a heat ſtill gentler than before. A whiter, purer, Volatile Salt will ſublime. Continue the diſtillation till an aqueous moiſture riſe, which will begin to diſſolve the Salt. At the bottom of the veſſel will be left a phlegm, with a little Oil floating on it. Keep your Salt in a bottle well ſtopped.

OBSERVATIONS.

IN the analyſis of any ſubſtance that yields a Volatile Alkali, this Salt is generally found in the receiver blended with the other principles of the mixt; which, aſcending from the retort in the form of liquors and vapours, diſſolve the Salt, or at leaſt moiſten it, and render it very impure. So that, if you deſire to have it without any mixture, recourſe muſt be had to a ſecond diſtillation, in order to ſeparate it from the heterogeneous matters with which it is confounded.

It is of conſequence in this diſtillation to apply but a very weak degree of heat; becauſe on that depends the ſucceſs of the operation, inſomuch that, the leſs heat you employ to ſublime the Salt, the purer it will be. For, being much more volatile than any of the other principles with which it is mixed, it muſt evidently riſe by itſelf, if no more heat be applied than is juſt neceſſary to elevate it; ſuch a heat being much too weak to raiſe the Oil and phlegm with which it is blended.

Neverthe1eſs, whatever care be taken to govern the heat, it is not poſſible to hinder this Volatile Salt from carrying up ſome portions of the principles mixed with it; thoſe, to wit, with which it is moſt cloſely united, and to which it hath by that means communicated a ſhare of its volatility. For this reaſon it requires a ſecond rectification, which is performed in the ſame manner as the former. But, ſeeing it is more volatile and lighter after the firſt rectification than before, being thereby freed from part of the heterogeneous matters with which it was loaded, a ſtill leſs degree of heat muſt be applied in this ſecond rectification.

The Oil with which the Volatile Salt is loaded, when but once diſtilled, is perceivable only by the yellow colour and weight it communicates thereto; becauſe it is cloſely united therewith, and in a perfectly ſaponaceous ſtate. This appears from the facility with which Volatile Salts, even the moſt oily, diſſolve in water, without diſcovering in the ſolution any ſeparation of the oily parts, and even without giving it a milky colour. But, in the ſecond rectification, this Oil becomes very perceptible; for it then ſeparates, in a great meaſure, from the Salt, and remains at the bottom of the cucurbite, floating on the phlegm, which is alſo ſeparated from the Salt.

The Salt is then whiter, more volatile, and purer; yet it is ſtill far from being brought to the utmoſt degree of purity, even by this ſecond rectification. It requires a third, a fourth, and even many more rectifications, to purify it perfectly: every rectification ſeparates from it ſome oily particles: and if you ſhould reſolve to go on rectifying till you can ſeparate no more Oil, there is reaſon to think this Salt would be entirely decompoſed; becauſe there is neceſſarily a certain quantity of Oil in its compoſition, without which it would not be a Volatile Alkali. You muſt therefore deſiſt from rectifying it any further, when you find it very white, and very light; and ſhut it up in bottles hermetically ſealed.

It often happens that Volatile Salts, though of a beautiful white after rectification, grow yellow after being kept ſome time in cloſe bottles. This is occaſioned by the Oil they contain diſengaging and diſcovering itſelf by degrees. To remedy this inconvenience Mr. Boerhaave propoſes to mingle the Volatile Salt you intend to purify with four times its weight of pulverized chalk, thoroughly dried, and even heated; to put the mixture into a glaſs alembic, and diſtill it with a gentle heat. By this means the Salt riſes exceeding pure and very white; becauſe the chalk abſorbs moſt of its Oil, and frees it therefrom. He adds, that Volatile Salt thus purified may be kept a long time, and will retain all its whiteneſs.

If a Volatile Alkali thus purified be combined, to the point of ſaturation, with an Acid, ſuch as the Marine Acid for inſtance; the reſult of this union, as we ſhall afterwards ſee, will be a Sal Ammoniac, from which the Volatile Alkali may be ſeparated by the intervention of a Fixed Alkali. A Volatile Alkali that hath paſſed through all theſe trials will then be in the higheſt degree of purity that Chymiſtry can bring it to; and appears conſtantly the ſame, from whatever ſubſtance it was originally obtained: which proves that if Volatile Alkalis, extracted from different vegetable and animal ſubſtances, ſeem to differ from each other in ſome reſpects, this can ariſe only from the heterogeneous matters with which they are mixed; but that, at bottom, they are all conſtituted of one ſingle principle, which is conſtantly the ſame, and exactly alike in them all.

It is of the laſt conſequence, on all occaſions where a Volatile Alkali is to be diſtilled in a concrete form, to make uſe of ſubliming veſſels with very large necks, that it may have room enough to make its way to the receiver with eaſe; for otherwiſe it may choak up the paſſage, and burſt the veſſels.

PROCESS II.

Volatile Alkalis combined with Acids. Sundry Ammoniacal Salts. Sal Ammoniac.

ON a Volatile Spirit or Salt pour gradually any Acid whatever. An efferveſcence will ariſe, and be more or leſs violent according to the nature of the Acid. Go on adding more Acid in the ſame manner, till no efferveſcence be thereby excited, or at leaſt till it be very ſmall. The liquor will now contain a ſemi-volatile Neutral Salt, called an *Ammoniacal Salt*; which may be obtained in a dry form by cryſtallizing as uſual, or by ſubliming it in cloſe veſſels, after the ſuperfluous moiſture hath been drawn off.

OBSERVATIONS.

VOLATILE Alkalis have the ſame properties with Fixed Alkalis, fixity only excepted: ſo that a Volatile Alkali muſt produce an efferveſcence when mixed with Acids, and form therewith Neutral Salts, differing from each other in nothing but the nature of the Acid in their compoſition.

It muſt be obſerved that the point of ſaturation is very difficult to hit, on this occaſion; owing probably to the Volatility of the Alkali, which, being much lighter than the Acid, tends always to poſſeſs the uppermoſt part of the mixture, while the Acid ſinks to the bottom: whence it comes to paſs that the lower part of the liquor is ſometimes overcharged with Acid, while the upper part is ſtill very Alkaline. But it is moſt eligible that the Alkali ſhould predominate in the mixture; becauſe the exceſs of this principle eaſily flies off while the moiſture is evaporating in order to the cryſtallization or ſublimation of the Ammoniacal Salt; which being only ſemi-volatile reſiſts the heat longer, and remains perfectly Neutral.

If the Vitriolic Acid be combined with a Volatile Alkali, and the mixture diſtilled in a retort to draw off the ſuperfluous moiſture, a liquor comes over into the receiver which ſmells ſtrong of a Sulphureous Acid. Now, as the Acid of Vitriol never becomes ſulphureous, but when it is combined with an inflammable matter, this experiment is one of thoſe which demonſtrate that Volatile Alkalis contain a very ſenſible quantity of inflammable matter. This ſame liquor taſtes of an Ammoniacal Salt; which proves that it carries up with it ſome of the Neutral Salt contained in the mixture. The reſt of this Salt, which is called *Glauber's Secret Sal Ammoniac*, or *Vitriolic Sal Ammoniac*, ſublimes into the neck of the retort. It is very pungent on the tongue; it crackles a little when thrown on a red-hot ſhovel, and then flies off in vapours.

The Ammoniacal Salt formed by the Acid of Nitre exhibits much the ſame phenomena; but it requires greater care in drying and ſubliming it, becauſe it hath the property of detonating all alone, without the addition of any other inflammable matter: and it will infallibly do ſo, if too ſtrong a fire be applied towards the end of the operation, when it begins to be very dry. This property of detonating by itſelf it derives from the inflammable matter contained in the Volatile Alkali which ſerves for its baſis: and this is another demonſtrative proof of the exiſtence of ſuch an inflammable matter in the Volatile Alkali. This Salt is called *Nitrous Ammoniacal Salt*.

With the vegetable Acids, that of vinegar for inſtance, is formed an Ammoniacal Salt of a ſingular nature, and which can ſcarce be brought to a dry form.

A Volatile Alkali, combined to the point of ſaturation with the Acid of Sea-ſalt, forms another Neutral Salt, which takes a concrete form either by ſublimation or cryſtallization. The cryſtals of this Salt are ſo very ſoft and fine, that a parcel of it looks like cotton or wool. This is the Salt properly called *Sal Ammoniac*. It is of great uſe in Chymiſtry and in manufactures: but that which is daily conſumed in great quantities is not made in the manner above mentioned. It would come extremely dear, if we had no other way of procuring it, but by forming it thus with the Acid of Sea-ſalt and a Volatile Alkali. This Salt, or at leaſt the materials of which it is formed, may be found in the fuliginoſities and ſoots of moſt animal, and of ſome vegetable ſubſtances. The greateſt part of what we uſe comes from Egypt, where vaſt quantities thereof are made.

The method of preparing Sal Ammoniac in Egypt was not known among us, till Meſſ. Lemaire and Granger, two of the Academy's correſpondents, gave in ſeveral Memoirs in which that buſineſs is deſcribed with great accuracy, from their own view on the ſpot. Their Memoirs inform us that chimney-ſoot alone, without any additament, is the matter from which they obtain their Sal Ammoniac; that thoſe chimneys under which nothing is burnt but Cow's-dung furniſh the beſt Soot. Six and twenty pounds of that Soot yield uſually ſix pounds of Sal Ammoniac.

" The operation takes up about fifty, or two and
" fifty hours. The veſſels in which they put the
" ſoot are ballons of very thin glaſs, terminating
" in a neck of fifteen or ſixteen lines long and an
" inch in diameter: but they are not all of the
" ſame ſize. The leaſt contain twelve pounds of
" Soot, and the greateſt fifty; but they fill them

"only three quarters full, in order to leave room
"for the ſublimation of the Salt.

"The furnace, in which they place theſe ballons, "conſiſts of four walls built in a quadrangular form. "The two front walls are ten and the ſides nine foot "long: but they are all five foot high and ten in- "ches thick. Within the quadrangle formed by "theſe walls three arches run lengthwiſe from end "to end thereof, at the diſtance of ten inches aſun- "der. The mouth of this furnace is in the middle "of one of its fronts, and of an oval form; two "foot four inches high, and ſixteen inches wide.

"The ballons lie in the ſpaces between the arches "of the furnace, which ſerve inſtead of a grate to "ſupport them. Four of them are uſually placed "in each interval; which makes ſixteen for one "furnace. They are ſet at the diſtance of about "half a foot from each other, and ſecured in their "places with brick and earth. But they leave "about four inches on the upper part of the ballon "uncovered, with a view to promote the ſublima- "tion, as they alſo do ſix inches of the inferiour "part, that the heat may the better act on the "matters to be ſublimed. Things being thus pre- "pared they firſt make a fire with ſtraw, which "they continue for an hour. Afterwards they "throw in Cow's dung made up in ſquare cakes "like bricks. (The want of wood in this country "is the reaſon that they generally make uſe of this "fewel.) Theſe cakes of dung add to the vio- "lence of the fire, which they continue in this "manner for nineteen hours; after which they in- "creaſe it conſiderably for fifteen hours more; and "then they ſlacken it by little and little.

"When the matter contained in the veſſels "begins to grow hot, that is, after ſix or ſeven "hours baking, it emits a very thick and ill-ſcented

" ſmoke, which continues for fifteen hours. Four " hours after that, the Sal Ammoniac is obſerved " to riſe in white flowers, which adhere to the in- " ſide of the neck of the veſſel; and thoſe who " have the direction of the operation take care " from time to time to paſs an iron rod into the neck " of the ballon, in order to preſerve a paſſage " through the ſaline vault, for giving vent to ſome " blueiſh vapours, which conſtantly iſſue out of the " veſſel during the whole operation."

From this hiſtory of the preparation of Sal Ammoniac it appears that Soot, and particularly the Soot of animal matters, either contains abundance of this Salt perfectly formed, and waiting only for ſublimation to ſeparate it therefrom, or, at leaſt, that it contains the proper materials for forming it; and that during the operation, which is a kind of diſtillation of Soot, theſe materials combine together and ſublime.

We ſhewed, in our analyſis of Soot, that this ſubſtance yields by diſtillation a great deal of Volatile Alkali; and this is an ingredient which makes at leaſt one half of Sal Ammoniac. As to the other principle of this Salt, I mean the Marine Acid, this alſo muſt needs exiſt in Soot: but it is not ſo eaſy to conceive how it ſhould come there.

It is very true that vegetable and animal ſubſtances, the only ones that produce Soot in burning, contain ſome portion of Sea-ſalt: but then this Salt is very fixed, and ſeems unfit to riſe with the Acid, the Oil, and the ſubtile Earth, of which the Volatile Alkali is formed. Therefore we muſt ſuppoſe either that its elevation is procured by the force of the fire, aided by the volatility of the matters that exhale in burning; or that, being decompoſed by the violence of the combuſtion, its Acid alone riſes with the other principles above mentioned. The latter ſeems probable enough: for though in the common operations of Chymiſtry the bare force of fire doth not ſeem ſufficient to decompoſe Sea-ſalt; yet the example of Sea-plants, which, before burning, contain this Salt in abundance, and whoſe aſhes contain ſcarce any at all, but are replete with its fixed part, that is, with its Alkaline baſis, ſeems to prove that, when this Salt is intimately mixed with inflammable matters, it may be deſtroyed by burning; ſo that its Acid ſhall deſert its baſis, and fly off with the Soot.

Before the exact method of procuring Sal Ammoniac was known, it was generally imagined that the manufacturers mixed Sea-ſalt, and even Urine, with the Soot; becauſe theſe two ſubſtances contain the principles of which this Salt conſiſts. But, beſides that the contrary now certainly appears from the above mentioned Memoirs, it hath been ſhewn by Mr. Duhamel, who hath publiſhed ſeveral Memoirs and experiments concerning the compoſition and decompoſition of Sal Ammoniac, from which we have partly taken what we have already ſaid on this ſubject, and which will furniſh us with ſome more curious obſervations; it hath been ſhewn, I ſay, in the firſt of theſe Memoirs printed with thoſe of the Academy for 1735, that the addition of Sea-ſalt to the Soot, from which Sal Ammoniac is to be extracted, contributes nothing to its production, and cannot increaſe its quantity. That alone, therefore, which was originally contained in the matters that produced the Soot, enters as a principle into the compoſition of Sal Ammoniac. We obſerved alſo, in treating of the analyſis of Soot, that Mr. Boerhaave obtained from it a conſiderable quantity of an Ammoniacal Salt without any additament.

Sal Ammoniac is ſometimes found perfectly formed in the neighbourhood of Vulcanos. This Salt is probably produced from the fuliginoſities of vegetable or animal matters conſumed by the fire of the Vulcano.

Sal Ammoniac is often impure, becauſe it carries up with it, in ſublimation, ſome of the black charred matter which ought to be left at the bottom of the veſſel: but it is eaſily purified. For this purpoſe you need only diſſolve it in water, filter the ſolution, then evaporate and cryſtallize; by which means you will have a very white and very pure Sal Ammoniac. You may, if you pleaſe, ſublime it again in a cucurbite and blind head, with a fire not too briſk. Some of it will riſe in the form of a light white powder, called *Flowers of Sal Ammoniac*. Theſe Flowers are no other than true Sal Ammoniac, which hath ſuffered no decompoſition; becauſe the bare action of fire is not capable of ſeparating the Acid and the Volatile Alkali, of which this Neutral Salt conſiſts. When you intend to decompoſe it, you muſt uſe the means to be mentioned hereafter.

Though Sal Ammoniac be only ſemi-volatile, and requires a conſiderable heat to ſublime it, yet it hath the property of carrying up with it matters that are very fixed and ponderous; ſuch as metallic ſubſtances, and ſome kinds of earths. For medicinal uſes we ſublime therewith Iron, Lapis Hæmatites, the Copper in blue Vitriol, &c. and then it takes different names, as *Martial Flowers of Sal Ammoniac*, *Ens veneris*, and other ſuch denominations, which it borrows from the matters ſublimed with it.

PROCESS III.

Sal Ammoniac decompounded by Acids.

INTO a large tubulated glaſs retort put a ſmall quantity of Sal Ammoniac in powder: ſet your retort in a furnace, and lute on a large ballon, as in the diſtillation of the ſmoking Acids of Nitre and Sea-ſalt. Through the hole in your retort pour a quantity of Oil of Vitriol or Spirit of Nitre equal in weight to your Sal Ammoniac. An effervеſcence will inſtantly follow. The mixture will ſwell, and diſcharge white vapours which will come over into the receiver. Stop the hole in the retort immediately, and let the firſt vapours paſs over, together with ſome drops of liquor, which will diſtill without fire. Then put a few coals into the furnace, and continue the diſtillation with a very gentle heat; which however muſt be increaſed little by little till nothing more will come over. When the operation is finiſhed, you will find in the receiver a Spirit of Salt if you made uſe of Oil of Vitriol; or an *Aqua regis*, if Spirit of Nitre was employed: and in the retort will be left a ſaline maſs, which will be either a Glauber's Secret Sal Ammoniac, or a Nitrous Sal Ammoniac, according to the nature of the Acid uſed to decompound the Sal Ammoniac.

OBSERVATIONS.

SAL Ammoniac, which conſiſts of the Marine Acid united to a Volatile Alkali, is, with reſpect to the Vitriolic and Nitrous Acids, juſt the ſame as Sea-ſalt is with reſpect to thoſe Acids; that is, the Vitriolic and Nitrous Acids, having a greater affinity, than the Marine Acid, with Volatile as well as Fixed Alkalis, will decompound the Sal Ammoniac, by expelling the Acid from its baſis, and aſſuming its place, juſt as they do with regard to Sea-ſalt. Moſt therefore of what was ſaid concerning the decompoſition of Sea-ſalt, and the diſtillation of its Acid, by the two other Acids, muſt be applied here.

We ſhall only obſerve, that, when the Acid of Sal Ammoniac is to be diſtilled from it by the interpoſition of the Vitriolic or Nitrous Acid, great care muſt be taken to put but a very ſmall quantity of this Salt into the retort; eſpecially if the Acids to be added are concentrated: for, as ſoon as they mix with the Sal Ammoniac, a great effervefcence ariſes, and the mixture ſwells to ſuch a degree, that, unleſs the quantity in the retort be very ſmall, it may run over all together into the receiver. It is alſo proper to take notice that this operation admits of but a ſmall degree of heat, for two reaſons; firſt, becauſe the Acid of the Sal Ammoniac, being very eaſily diſlodged by an Acid ſtronger than itſelf, riſes alſo very eaſily; ſecondly, becauſe the Sal Ammoniac which is to be decompounded, as well as the Ammoniacal Salts which reſult from its decompoſition, are ſemi-volatile, and will ſublime in ſubſtance if they be expoſed to the ſmalleſt exceſs of heat. Moreover, the Nitrous Sal Ammoniac would be in danger of taking fire and exploding, for a reaſon frequently mentioned above.

The Nitrous Sal Ammoniac may be decompounded, as well as Sal Ammoniac, by the Vitriolic Acid. But, as the Nitrous Acid contained in the Salt is the ſtrongeſt of all Acids next to the Vitriolic, no other Acid but this is able to expell it from its baſis; in which reſpect this Salt reſembles Nitre.

Inſtead of employing the Acids of Vitriol and Nitre to decompound Sal Ammoniac, we might make uſe of Neutral Salts conſiſting of theſe Acids combined with metallic or earthy baſes: but then, as this decompoſition can not be effected without a greater degree of heat, there is reaſon to apprehend that ſome of the Sal Ammoniac would be thereby ſublimed before it could be decompounded.

PROCESS IV.

Sal Ammoniac decompounded by Fixed Alkalis. Volatile Salt. The Febrifuge of Sylvius.

INTO a glaſs alembic or retort put Sal Ammoniac and Salt of Tartar pulverized and mixed together in equal quantities. Set your veſſel in a proper furnace, and immediately lute on a large receiver. A little Volatile Spirit will aſcend; and a Volatile Alkali, in a concrete form, very white and beautiful, will ſublime into the head, and come over into the receiver, in quantity near two thirds or three fourths of the Sal Ammoniac uſed. Continue the diſtillation, increaſing the fire by degrees, till nothing more will ſublime. Then unlute the veſſels. Put up your Volatile Salt immediately into a wide-mouthed bottle, and ſtop it cloſe with a cryſtal ſtopple. At the bottom of the retort, or cucurbite, you will find a ſaline maſs, which, being diſſolved and cryſtallized, will form a Salt nearly cubical, having the taſte and other properties of Sea-ſalt. This is the *Sal Febrifugum Sylvii.*

OBSERVATIONS.

THIS decompoſition of Sal Ammoniac is the reverſe of that in the preceding proceſs. In the former operation it was ſhewn that the Acid of Sal Ammoniac may be ſeparated from its baſis by applying to that baſis a ſtronger Acid: in the preſent operation, on the contrary, the baſis of this Salt is ſeparated from its Acid by preſenting to that Acid a Fixed Alkali, wherewith it hath a greater affinity than with the Volatile Alkali which ſerves it for a baſis.

The action of Fixed Alkalis upon Sal Ammoniac is ſo vigorous and ſudden, that, as ſoon as theſe two matters are mixed together, the Volatile urinous Salt ruſhes out with great activity, even without the help of heat; ſo that much of it will be loſt if care be not taken to confine the mixture immediately in thoſe veſſels by means of which it is to be diſtilled.

The Volatile Salt obtained by this operation is white, pure, and very active; having been freed from the greateſt part of its ſuperfluous fat matter, both by the union it had contracted with the Marine Acid, and by the Fixed Alkali employed to ſeparate it therefrom. This Salt is ſo quick and volatile, that if, on taking it out of the receiver, it be left a little too long expoſed to the air, before it be put into the bottle in which it is to be kept, a great deal of it will exhale and be loſt. For the ſame reaſon care ſhould be taken, while the veſſels are unluting, that the vapour of this Salt do not ſtrike the organ of ſmelling, or be drawn into the lungs in reſpiration; for it affects thoſe organs ſo powerfully, and makes ſuch a quick impreſſion on them, that the operator would be in danger of ſuffocation. Yet it is of great ſervice, when cautiouſly ſmelled to, for exciting the vibrations of the *Genus Nervoſum*, in Apoplexies, Fainting fits, and Hyſterical diſorders. But it muſt always be adminiſtered with great caution; for it hath a corroſive quality, and is no leſs cauſtic than a Fixed Alkali. This is proved by applying it to the bare ſkin, and keeping it on by means of a pitch-plaſter, ſo that it cannot fly off in vapours: for, as ſoon as it begins to grow warm, it produces on the ſkin a ſmarting ſenſation like that of burning, attended with much pain, and in a very ſhort time makes an eſchar like a cauſtic.

The Volatile Spirit, obtained in the decompoſition of Sal Ammoniac by a Fixed Alkali, derives its origin from the Phlegm contained in the ſaline matters that are mixed together on that occaſion. The moiſter thoſe matters are, the more Spirit there will be. This alſo is very active and penetrating. But as it owes theſe qualities wholly to the Volatile Salt diſſolved in it, the more of this Spirit comes off, the leſs Salt will there be.

If you deſire to have much Volatile Spirit, a quantity of water, proportioned to the quantity of Spirit you want, muſt be mixed with the Salts. In this caſe the diſtillation begins with a humid vapour which coagulates on the ſides of the receiver into a concrete Salt, almoſt as ſoon as it comes over. There riſes afterwards an aqueous vapour, not ſo ſaline or volatile as the former. This liquor diſſolves the Salt that was coagulated before; and, if the water added was in ſufficient quantity, it will diſſolve the Salt entirely; otherwiſe it will diſſolve but a part thereof, and then it is certain that the liquor is a Volatile Spirit as ſtrongly impregnated with Salt as it can be. The reaſon why the liquor that riſes firſt contains a great deal more Volatile Salt than the other, in ſo much that it coagulates and becomes ſolid, is becauſe the Volatile Salt riſes in diſtillation much more eaſily than water.

In whatever manner the Volatile Spirit or Salt be diſtilled from Sal Ammoniac, by means of a Fixed Alkali, we always find at the bottom of the retort, or cucurbite, when the operation is finiſhed, a new Neutral Salt compounded of the Acid of the Sal Ammoniac, and of the Alkali uſed in the diſtillation. If the Salt of Tartar be uſed, this new Neutral Salt will be perfectly like that produced by combining this Alkali with the Acid of Sea-ſalt, to the point of ſaturation. The figure of the cryſtals of this Salt, though much like that of the cryſtals of Sea-ſalt, is nevertheleſs a little different. However, this Salt poſſeſſes the chief properties of Sea-ſalt. It bears the name of *Sal Febrifugum Sylvii*, becauſe that Phyſician attributed to it the virtue of curing intermitting fevers. But its title to this virtue is very doubtful, at leaſt in this country.

If the Salt of Soda be uſed, inſtead of Salt of Tartar, to decompound Sal Ammoniac, a Volatile Spirit and Salt will in like manner be obtained; and the Neutral Salt left in the retort, after diſtillation, will be a true regenerated Sea-ſalt, perfectly like native Sea-ſalt; becauſe, as we have ſaid before, the Salt of Soda is of the ſame kind with the natural baſis of Sea-ſalt; and the inconſiderable differences, obſervable between the *Sal Febrifugum* and Sea-ſalt, can be attributed only to ſuch as may be found between the Alkaline baſes of thoſe two Salts.

PROCESS V.

Sal Ammoniac decompounded by Abſorbent Earths and Lime. The Volatile Spirit of Sal Ammoniac. Fixed Sal Ammoniac. Oil of Lime.

LET one part of Sal Ammoniac and three parts of Lime ſlaked in the air be pulverized ſeparately, and expeditiouſly mixed together. Put this mixture immediately into a glaſs retort, ſo large that half of it may remain empty. Apply thereto a capacious receiver, with a ſmall hole in it to give vent to the vapours, if needful. Let your retort ſtand in the furnace about a quarter of an hour, without any fire under it. While it ſtands thus a great quantity of inviſible vapours will riſe, condenſe into drops, and form a liquor in the receiver. Then put two or three live coals in your furnace, and gradually increaſe the fire till no more liquor will riſe. Now unlute your veſſels, taking all poſſible care to avoid the vapours, and quickly pour the liquor out of the receiver into a bottle, which you muſt ſtop with a cryſtal ſtopple rubbed with emery. There will remain, at the bottom of the retort, a white maſs, conſiſting of the Lime employed in the diſtillation, together with the Acid of the Sal Ammoniac: this is called *Fixed Sal Ammoniac.*

OBSERVATIONS.

IN our Elements of the Theory, we explained how we imagine that Lime and other ſubſtances, which, according to the Table, have leſs affinity than Volatile Alkalis with Acids, are nevertheleſs capable of decompounding Sal Ammoniac, by uniting with its Acid, after expelling it from its baſis, which is a Volatile Alkali. To recapitulate our opinion in two words: we conceive this to depend on the fixedneſs of theſe earthy and metallic additaments, which enables them to reſiſt the force of fire, and on the volatility of the baſis of Sal Ammoniac, which proves a great diſadvantage to it when it comes to ſtruggle, as it were, with thoſe fixed additaments, aided by a conſiderable degree of heat. We ſhall only obſerve that we are not ſingular in this opinion, nor indeed did we deliver it as a new one; that ſeveral modern Chymiſts concurr with us therein, and particularly Mr. Baron, whom we have already mentioned more than once on the ſubject of Borax; and who, we think, was the firſt that ever took particular notice of it in print, viz. in his Memoirs on Borax, communicated to the Academy before the publication of our Elements. For the explanation of this phenomenon, therefore, we refer to thoſe Memoirs, which are actually publiſhed, and to what we have already ſaid on the ſubject in our treatiſe above mentioned.

Another phenomenon, which is equally ſingular and curious, furniſhes us with matter for ſeveral reflections, and gives us occaſion to relate, in few words, the reſult of Mr. Duhamel's moſt ſagacious experiments and ſpeculations tending to diſcover the cauſe thereof. The point under conſideration is the different forms and properties which the Volatile Alkali aſſumes, when ſeparated from Sal Ammoniac by the means of a Fixed Alkali, and by the means of Lime. We know that the former is always in a concrete form, unleſs the mixture, from which it is diſtilled, be abſolutely drowned with water; and that the latter, on the contrary, is always in a fluid form, and conſtantly liquid, whatever method be taken to diſtill it.

Some Chymiſts imagine that the Volatile Salt of Sal Ammoniac appears in a concrete form, only becauſe it ſtill contains ſome Acid; whence they conclude that the reaſon why no concrete Volatile Salt can be obtained by the means of Lime is, becauſe it abſorbs all the Acid of the Sal Ammoniac; which is not the caſe, they ſay, with Fixed Alkalis. Others impute the conſtant fluidity of the Volatile Spirit of Sal Ammoniac, obtained with Lime, to the particles of fire which they ſuppoſe communicated thereto by that ſubſtance. Mr. Duhamel equally refutes both theſe opinions, by proving from experiments that Fixed Alkalis are capable of abſorbing as much Acid as Lime can, and even more; and that, having been calcined as long and with as violent a fire as Lime, they muſt contain and communicate as many particles of fire; if indeed it be poſſible that the particles of fire ſhould actually be lodged, and continue impriſoned, in calcined ſubſtances, as theſe gentlemen ſuppoſe. Yet this is contrary to experience; ſeeing the Volatile Salt diſtilled by the means of a Fixed Alkali, though ever ſo long and ever ſo violently calcined, is always in a concrete form, and doth not reſemble the Volatile Spirit of Sal Ammoniac prepared with Lime.

In order to throw the neceſſary lights on this point, Mr. Duhamel had recourſe to the only method that can be depended on in Natural Philoſophy; namely, Experiments. He accordingly made ſeveral, of which theſe are the chief.

Firſt, he diſtilled a Volatile Salt, by the means of well deſiccated Salt of Tartar and Salt of Soda; and, urging the fire with great violence towards the end of the operation, he thus obtained a quantity of Volatile Salt equal to, or even exceeding, that of the Sal Ammoniac he uſed: whence he juſtly concluded that, on this occaſion, the Volatile Salt carried up and volatilized ſome of the Fixed Salt.

Secondly, he found upon trial that the Volatile Spirit, obtained from Sal Ammoniac by the means of Lime, appears in the form of a liquor, only becauſe it is mixed with ſome water which was contained in the Lime. Of this truth he had the following deciſive proof: having attempted to prepare a Volatile Spirit of Sal Ammoniac with Lime, which had not been ſlaked, either in the air or by water, he could not obtain any Volatile Spirit; or, at leaſt, the quantity was ſo ſmall that it might be reckoned as nothing; and even that was wholly due to the moiſture which Sal Ammoniac neceſſarily contains, together with that which Lime imbibes from the air, if ever ſo little expoſed thereto.

From theſe two experiments Mr. Duhamel draws the following conſequences: viz. that the Volatile Salt cannot be ſeparated from the Sal Ammoniac and ſublimed, without carrying along with it ſome of the additament which ſerves to extricate it; or, inſtead thereof, ſome other body with which it is capable of uniting: that Fixed Alkalis have the property of being thus carried up by the Volatile Alkali, and ſubliming with it: that the caſe is not the ſame with Lime, which therefore cannot, when alone, ſeparate and ſublime the Volatile Alkali of the Sal Ammoniac; but becomes capable thereof when it hath imbibed any moiſture, which joins with the Volatile Salt, and riſes therewith in diſtillation. And hence it muſt be concluded, that, ſeeing the Volatile Salt carries up with it ſome of the Fixed Alkali by the means whereof it is ſeparated, it muſt be in a concrete form; what it carries up along with it being dry and ſolid: whereas, when it is diſtilled with Lime, it cannot but be liquid, ſeeing it muſt needs be diſſolved by the moiſture it gets from the Lime, without which it would not riſe.

But to what muſt we attribute theſe effects produced by Lime, ſo different from thoſe produced by Fixed Alkalis. Are they owing to its quality of Lime? or would it produce the ſame, if it were only a mere Abſorbent Earth? Mr. Duhamel hath anſwered this queſtion by a third ſort of experiment. He tried to decompound Sal Ammoniac, and to ſeparate its Volatile Alkali, by a pure Abſorbent Earth, without mixing any water with it, or calcining it.

For this purpoſe he made uſe of Chalk; and his experiment ſucceeded. By means of this additament he decompounded Sal Ammoniac, and by the experiment obtained the lights he wanted. The Volatile Alkali, being extricated by the dry but uncalcined Chalk, roſe in a concrete form, as with Fixed Alkalis; and in like manner carried up with it ſome of the earthy additament. The ſame Chalk when calcined, and converted into Lime, produced the very effect of Lime on Sal Ammoniac. It is therefore from calcination alone that Abſorbent Earths derive the property of retaining obſtinately the Volatile Alkali, and preventing its ſublimation by refuſing to riſe with it as Fixed Alkalis do.

Though theſe ingenious experiments evidently furniſh us with great lights for diſcovering the cauſe of the ſolidity or fluidity of the Volatile Alkali, when ſeparated from Sal Ammoniac by different additaments, as they fully determine ſeveral preliminary queſtions immediately relating thereto, yet they ſtill leave us, in ſome meaſure, at a loſs with regard to the chief point. For we do not yet know why Fixed Alkalis and Abſorbent Earths, which, in all Chymical tryals, ſhew that they have certainly as much fixity as Lime, are carried up by the Volatile Alkali, while Lime reſiſts, inſtead of riſing with it as thoſe other ſubſtances do, obſtinately retains it, and even fixes it in ſome meaſure, ſo that it is impoſſible for it to ſublime. This queſtion, in my opinion, depends on the theory of Lime; nor can we hope to reſolve it, in its full extent, till we get a further inſight into the nature of that ſingular ſubſtance than we have at preſent.

On this ſubject, however, Mr. Duhamel hath offered ſome conjectures founded on the known properties of Lime, and ſupported by experiments. " Lime, ſays he, is an earth freed by calcination " from almoſt all its humidity, almoſt all its Acid, " and all the fat it contained; whether that fat " came from ſome animal parts, as is the caſe of " thoſe ſtones which conſiſt of ſhells; or whether " it were a bituminous fat, as may happen to be " the caſe with ſome others: this ſubſtance is " withall acrid and fiery; it is very greedy of moiſ- " ture, and imbibes it when expoſed thereto. It " abſorbs Acids, and retains them ſtongly; and, " laſtly, it unites with fat matters, and therewith " makes a kind of ſoap."

All theſe properties are verified by experiments; and therefore Mr. Duhamel thinks he hath a right to ſay, that Lime acts not only on the Acid of Sal Ammoniac, but alſo on the fatty matter which always accompanies Volatile Alkalis, and is eſſential to their nature; and therefore it decompounds them. Of this Mr. Duhamel gives the following convincing proof founded on experiment. He took ſome Volatile Spirit diſtilled with Lime, and abſtracted it ſeveral times from a freſh parcel of Quick-Lime. The quantity of the Spirit diminiſhed ſenſibly every time; and the Lime was at laſt ſo replete with fat, that the Vitriolic Acid, when poured thereon, became very ſulphureous; and moreover, when calcined in a crucible, it emitted a very perceptible ſmell of burnt greaſe.

Indeed Fixed Alkalis are alſo capable of abſorbing and retaining fat matters; but not near ſo ſtrongly as Lime: becauſe theſe Salts are never entirely freed from that which they contain originally; whereas Lime ſeems much poorer, and abſolutely void of any oily matter.

On theſe principles Mr. Duhamel reſolved to try if he could not obtain a Volatile Alkali in a concrete form, by diſtilling the Volatile Spirit from Lime brought nearly to the condition of a Fixed Alkali by imbibing a portion of fat matter. With this view he diſtilled a great quantity of Volatile Spirit from a little Lime, and actually obtained a ſmall portion of Volatile Salt; becauſe the great quantity of Volatile Spirit had, in ſome meaſure, ſaturated the Lime with fat matter.

Mr. Duhamel tried alſo to bring Lime back to the condition of a pure Abſorbent Earth, to *decalcine* it, if I may uſe the term; in order to try whether he could not by this means make it produce the ſame effect as Chalk. For this purpoſe he lixiviated ſome Lime four months ſucceſſively, pouring every day freſh water on it, and removing that of the preceding day, together with the cryſtalline cruſt which always formed on it; and after leaving this Lime two years in the ſhade, he applied it to Sal Ammoniac. It produced a moderate quantity of Volatile Salt, which was very tranſparent, and ſeemed to be cryſtallized in cubes. Thus we ſee Lime rendered very like Chalk. Yet it was pretty acrid on the tongue, and the Volatile Salt, obtained by its means, was more diſpoſed to run into a liquid than that ſeparated by Chalk: which ſhews that this Lime ſtill retained ſome part of its former character, and that its transformation was not complete.

To conclude what relates to the Volatile Alkali of Sal Ammoniac, it only remains that we ſay a word or two of that portion of the earthy or ſaline additament, which, though fixed in its nature, ſublimes nevertheleſs with the Volatile Alkali, and gives it a concrete form.

Mr. Duhamel, who, in every ſubject that he handles, omits nothing worthy of attention, made ſeveral other experiments, with a view to diſcover whether or no the Salt of Tartar and the Chalk carried up by the Volatile Alkali be truly volatilized; and whether or no there be ſuch a ſtrict union contracted between the Urinous Salt and theſe fixed ſubſtances, that the whole reſults in what is called a *Concrete Volatile Salt*; or if thoſe fixed ſubſtances be united but ſuperficially with the Urinous Salt, which only carries them up along with itſelf in ſublimation, as Sal Ammoniac carries up ſeveral very fixed metallic matters.

The reſult of the experiments made by Mr. Duhamel for this purpoſe is, that the fixed ſubſtances carried up by the Volatile Alkali of the Sal Ammoniac are actually volatilized; that they make, as it were, one whole with it; and are ſo cloſely combined therewith, that almoſt all the moſt efficacious means of ſeparating fixed from volatile matters are unſucceſsful with regard thereto. Nothing, for inſtance, is fitter to ſeparate a volatile ſubſtance from a fixed one, than to mix the compound with a great quantity of water, and to diſtill the whole with ſuch a degree of heat as ſhall be exactly ſufficient to elevate the volatile part. In this manner Mr. Duhamel treated Volatile Alkalis replete with Fixed Salt and with Chalk: but though he applied no more than the gentleſt degree of heat; nay, expoſed his mixture to the air only, fearing leſt he ſhould make the heat too ſtrong if he uſed fire; yet the fixed part, which the Volatile Salt had carried up with it, continued ſtill united therewith; ſo that the whole paſſed over in diſtillation, or was diſſipated by evaporation, without leaving any thing fixed at the bottom of the veſſel.

He alſo juſtly looked on Acids as an effectual means of procuring the ſeparation or decompoſition he was in queſt of. We know that, with the Volatile Alkali, they form Ammoniacal Salts, which, though they are not ſo light as the Volatile Alkali, ſublime nevertheleſs with a moderate heat; and that, on the contrary, the ſame Acids, with Fixed Alkalis or Abſorbent Earths, form Neutral Salts, which reſiſt the violence of fire. On this principle Mr. Duhamel poured Acids, to the point of ſaturation, upon Volatile Alkalis containing much Fixed Alkali or Chalk. But this experiment ſucceded no better than the foregoing; for the mixture being put to diſtill, ſublimed wholly in Sal Ammoniac. Indeed a little fixed matter was left at the bottom of the retort; but the quantity thereof was too ſmall to merit notice.

At laſt, the only way Mr. Duhamel could think of, for ſeparating from a Concrete Volatile Alkali the fixed parts which that Salt had rendered volatile, was to expoſe it to the air, covered with a bit of gauze only; but in its dry ſtate, without diſſolving it in water. The Volatile Urinous Salt was by this means diſſipated; having deſerted the fixed part, which remained at the bottom of the baſon, and, being expoſed to the fire, retained its fixed nature. But it took more than a year to effect this ſeparation; nor are we ſure that it was complete: for it is not certain that all the fixed part was left behind, and that ſome of it was not diſſipated with the Volatile Urinous Salt.

This volatilization, this kind of metamorphoſis of a Fixed Alkali and an Abſorbent Earth into a Volatile Alkali, is a very curious phenomenon, and deſerves to be conſidered by the beſt Chymiſts.

We ſhall finiſh our obſervations on the decompoſition of Sal Ammoniac by Lime, with ſome reflections on the nature of the *caput mortuum* that remains after this diſtillation.

This reſiduum is only Lime impregnated, but not ſaturated, with the Acid of Sea-ſalt. If the diſtillation be urged at laſt with a violent fire, the *caput mortuum* will be found formed into a maſs, which ſeems to have been half-melted. This matter is a kind of Phoſphorus, and emits light in the dark, when ſtruck with any hard body. Mr. Homberg was the firſt who diſcovered it to have this property. Having calcined, and melted together in a crucible, one part of Sal Ammoniac and two parts of Lime, with a deſign to fix that Salt, he obſerved the maſs remaining after the fuſion to have the property juſt mentioned.

Lime, thus impregnated with the Acid of Sal Ammoniac, is very improperly called by the name of *Fixed Sal Ammoniac.* This compound attracts the moiſture of the air, and even runs wholly into a liquid, if it be impregnated with much Acid. It hath almoſt all the properties of Fixed Alkalis, This liquid is called *Oil of Lime*, for the ſame reaſon that deliquated Salt of Tartar is called *Oil of Tartar*.

PROCESS VI.

Volatile Alkalis combined with Oily matters. A Volatile Oily Aromatic Salt.

PULVERIZE and mix together equal parts of Sal Ammoniac and Salt of Tartar: put the mixture into a glaſs or ſtone cucurbite: pour on it good Spirit of Wine till it riſe half an inch above the matter. Mix the whole with a wooden ſpatula; apply a head and a receiver, and diſtill in a ſand-bath, gently heated, for two or three hours. A Volatile Salt will riſe into the head; and then the Spirit of Wine will diſtill into the receiver, carrying with it a portion of the Volatile Salt.

When nothing more will come over, let your veſſels cool; then unlute them, ſeparate the Volatile Salt, and weigh it directly. Return it into a glaſs cucurbite, and for every ounce thereof add a dram and a half of Eſſential Oil, drawn from one or more ſorts of aromatic plants. Stir the whole with a wooden ſpatula, that the Eſſence may incorporate thoroughly with the Volatile Salt. Cover the cucurbite with a head, fit on a receiver, and, having luted it exactly, diſtill in a ſand-bath, as before, with a very gentle heat. All the Volatile Salt will riſe, and ſtick to the head. Let the fire go out, and when the veſſels are cooled take your Salt out of the head. It will have an odour compounded of its own proper ſmell, and the ſmell of the Eſſence with which it is combined. This is an *Aromatic Oily Salt*. Put it into a bottle ſtopped cloſe with a cryſtal ſtopple.

OBSERVATIONS.

THE deſign of this operation is to incorporate and unite an Oil with a Volatile Alkali. In order to prepare it for receiving the Oil and combining more eaſily therewith, Spirit of Wine is added in the diſtillation of the Volatile Salt intended for this purpoſe. This Salt hath the property, as was ſhewn in the preceding operation, to carry up with it part of the ſubſtances with which it is diſtilled. On this occaſion, therefore, it is impregnated with a little of the Spirit of Wine; and this Spirit, which contains in itſelf an oily matter, and is the ſolvent of Oils, cannot fail to facilitate the union of the Oil with the Volatile Salt, as it ſerves for a medium between them. Yet it muſt not be conſidered as a neceſſary one. A Volatile Salt, ſublimed with Salt of Tartar alone, would alſo very readily take up any Oil with which it ſhould be diſtilled. We have ſeen that Volatile Alkalis are originally impregnated with much Oil, which is radically diſſolved in them; and conſequently they have a great affinity with that ſubſtance. So that if we diſtill them with Spirit of Wine, at the beginning of this operation, we do it not out of any neceſſity, but only with a view to accelerate or facilitate the intended union.

In this diſtillation the Volatile Alkali always riſes firſt, and before the Spirit of Wine; which proves that it is much more volatile, though it be more ponderous than the Spirit.

If the Spirit of Wine uſed in this diſtillation be very aqueous, it will diſſolve the Salt as it comes over, and will reduce it into a Spirit: but if, on the contrary, it be well dephlegmated, the Volatile Alkali will remain in a concrete form, and will not be diſſolved in this firſt diſtillation.

If you deſire to have the Volatile Salt entirely diſſolved in the Spirit of Wine, though highly dephlegmated,

phlegmated, it muſt be repeatedly diſtilled a great number of times with the ſame Spirit of Wine: for, though the ſmall quantity of Spirit of Wine, with which it unites in the firſt diſtillation, be not capable of reducing it into a liquid, yet, as it takes up more and more every time it is diſtilled, it diſſolves at laſt, and then with the Spirit of Wine forms a fluid that appears perfectly homogeneous. The Volatile Alkali is now rendered conſiderably milder by the union thus contracted, and is accordingly called the *Dulcified Volatile Spirit of Sal Ammoniac.*

When well dephlegmated Spirit of Wine is mixed with a Volatile Spirit of Sal Ammoniac, perfectly ſaturated with Volatile Salt, theſe two liquors together immediately form a white opaque *coagulum.* But for this purpoſe you muſt not uſe a Volatile Spirit diſtilled with Lime; for then the experiment will not ſucceed.

This *coagulum* does not ſeem to be the effect of an intimate union between the two ſubſtances mixed together, like that which reſults from the union of a Fixed Alkali with an Oil. It hath juſt now been ſhewn that Spirit of Wine and a Volatile Alkali do not readily unite together. I believe the effect rather depends on this, that Spirit of Wine hath a greater affinity than the Volatile Salt with water; and therefore the Spirit, which ought to be perfectly dephlegmated, attracts the water wherein the Volatile Salt was diſſolved, which thereupon recovers its concrete form; and being at that time mixed with the Spirit of Wine, it keeps that Spirit locked up among its parts, and hinders it from appearing with its natural fluidity.

What confirms this notion is, that the *coagulum,* which at firſt ſeems to make but one whole, ſoon ſeparates into two parts, whereof one, which is ſolid and nothing but the Volatile Salt concreted, lies at the bottom of the veſſel; and the other, which is fluid, cannot be miſtaken for any thing but the Spirit of Wine, which, being diſengaged from the particles of Salt, recovers the form of a liquid, and, being the lighteſt, floats over the Salt. Yet theſe two ſubſtances, though now very diſtinct from each other, are not ſo pure as before they were mixed together. The Spirit of Wine hath diſſolved a little of the Volatile Salt; and, on the other hand, the Volatile Salt retains a little of the Spirit of Wine. They may indeed be perfectly united and blended with each other, by the method above delivered; that is, by being frequently diſtilled and cohobated together, till they form one mixt; but then that mixt will be in a liquid form.

The firſt time this mixture is diſtilled, a great deal of Volatile Salt riſes firſt, which is very fit to unite with an Eſſential Oil, and ſo to be made a Volatile Oily Aromatic Salt.

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